PB84-154798

Review of New Source Performance Standards for Kraft Pulp Mills

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Sep 83

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-154798

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-83-017
September 1983

Air

EPA

Review of New Source Performance Standards for Kraft Pulp Mills

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

NSPS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/3-83-017		PB84 154798

4. TITLE AND SUBTITLE	5. REPORT DATE
Review of New Source Performance Standards for Kraft Pulp Mills	September 1983
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS DAA for Air Quality Planning and Standards Office of Air and Radiation U.S. Environmental Protection Agency, RTP, N.C. 27711	13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA 200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report reviews the current New Source Performance Standards for Kraft Pulp Mills. It includes a summary of the current standards, the status of current applicable control technology, and the ability of mills to meet the current standards. Recommended changes to the existing standards are discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Kraft Pulp mills Particulate matter Total Reduced Sulfur Standards of Performance Pollution Control	Air Pollution Control	13 B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	Unclassified	82
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-450/3-83-017

Review of New Source Performance Standards for Kraft Pulp Mills

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

September 1983

10

This report has been reviewed by the Emission Standards and Engineering Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication, Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, or from National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

TABLE OF CONTENTS

		Page
LIST OF ILLUSTRATIONS		viii
LIST OF TABLES		ix
1.	EXECUTIVE SUMMARY	1-1
1.1	BEST DEMONSTRATED CONTROL TECHNOLOGY	1-1
1.2	ECONOMIC CONSIDERATIONS AFFECTING THE NSPS	1-2
1.3	RECOMMENDATIONS ON REVISION OF CURRENT NSPS	1-3
1.4	RECOMMENDATIONS ON EXTENSION TO THE NSPS	1-4
2.	THE KRAFT PULPING INDUSTRY	2-1
2.1	INTRODUCTION	2-1
2.2	BACKGROUND INFORMATION	2-1
2.3	DESCRIPTION OF INDIVIDUAL PROCESS FACILITIES AND THEIR EMISSIONS	2-4
2.3.1	Digester System	2-4
2.3.2	Brown Stock Washer System	2-7
2.3.3	Multiple-Effect Evaporator System	2-10
2.3.4	Recovery Furnace System	2-12
2.3.5	Smelt Dissolving Tank	2-17
2.3.6	Lime Kiln	2-17
2.3.7	Black Liquor Oxidation System	2-20
2.3.8	Condensate Stripping Sytem	2-21
2.4	INDUSTRY CHARACTERIZATION	2-21
2.5	SELECTION OF KRAFT PULP MILLS FOR NSPS CONTROL	2-21
2.6	REFERENCES	2-23
3.	CURRENT STANDARDS FOR KRAFT PULP MILLS	3-1
3.1	AFFECTED FACILITIES	3-1
3.2	CONTROLLED POLLUTANTS AND EMISSION LEVELS	3-1
3.3	NSPS IMPACT ON EXISTING KRAFT PULP MILLS	3-2
3.4	STATE REGULATIONS	3-2
3.5	TESTING AND MONITORING REQUIREMENTS	3-3
3.5.1	Testing Requirements	3-3
3.5.2	Monitoring Requirements	3-4
4.	STATUS OF CONTROL TECHNOLOGY	4-1
4.1	PARTICULATE CONTROL	4-1
4.1.1	Recovery Furnace	4-1
4.1.2	Smelt Dissolving Tanks	4-6
4.1.3	Lime Kiln	4-6

TABLE OF CONTENTS (Continued)

		Page
4.2	TRS CONTROL	4-7
4.2.1	Recovery Furnace System	4-7
4.2.2	Digester and Multiple-Effect Evaporator Sytems	4-8
4.2.3	Brown Stock Washer System	4-8
4.2.4	Black Liquor Oxidation System	4-9
4.2.5	Smelt Dissolving Tank	4-9
4.2.6	Lime Kiln	4-9
4.2.7	Condensate Stripping System	4-10
4.3	REFERENCES	4-11
5.	COMPLIANCE TEST RESULTS	5-1
5.1	ANALYSIS OF NSPS COMPLIANCE TEST RESULTS	5-1
5.1.1	Recovery Furnace System	5-1
5.1.2	Smelt Dissolving Tanks	5-3
5.1.3	Lime Kiln	5-5
5.2	REFERENCES	5-8
6.	COST ANALYSIS	6-1
6.1	UPDATE COST FOR THE AFFECTED FACILITIES	6-1
6.1.1	Particulate Control	6-3
6.1.2	TRS Control	6-3
6.2	REFERENCES	6-7
7.	ENFORCEMENT ASPECTS	7-1
7.1	REFERENCES	7-3
8.	ANALYSIS OF POSSIBLE REVISIONS TO THE STANDARDS	8-1
8.1	POSSIBLE REVISIONS TO NSPS	8-1
8.1.1	Recovery Furnace Systems	8-1
8.1.2	Smelt Dissolving Tanks	8-4
8.1.3	Lime Kiln	8-5
8.1.4	Digester and Multiple-Effect Evaporator Systems	8-7
8.1.5	Brown Stock Washer Systems	8-7
8.1.6	Black Liquor Oxidation Systems	8-8
8.1.7	Condensate Stripping Systems	8-8
8.1.8	Exemption for Brown Stock Washers and Black Liquor Oxidation Systems	8-9
8.2	POSSIBLE REVISIONS TO MONITORING REQUIREMENTS	8-9
8.3	EXTENSION TO OTHER SOURCES	8-10
8.4	EXTENSION TO OTHER EMISSIONS	8-11
8.5	REFERENCES	8-13

TABLE OF CONTENTS (Concluded)

		Page
9.	CONCLUSIONS AND RECOMMENDATIONS	9-1
9.1	REVISION OF THE CURRENT STANDARDS	9-1
9.1.1	Conclusions Based on Control Technology	9-1
9.1.2	Conclusions Based on Economic Considerations	9-1
9.1.3	Conclusions Based on Other Considerations	9-2
9.1.4	Recommendations on Revision of Current Standards	9-2
9.2	EXTENSION OF STANDARDS	9-3
9.2.1	Conclusions Based on Control Technology	9-3
9.2.2	Recommkendations on Extension of Standards	9-3
APPENDIX A.	Kraft Pulp Mills Subject to the NSPS	A-1

LIST OF ILLUSTRATIONS

Figure Number		Page
2-1	Kraft Pulping Process	2-3
2-2	Batch Digester Flow Sheet	2-8
2-3	Continuous Digester Flow Sheet	2-9
2-4	Continuous Diffusion Washer	2-11
2-5	Direct Contact (Conventional) Recovery Furnace System with Black Liquor Oxidation	2-14
2-6	Indirect Contact Recovery Furnace System	2-15
2-7	Fluidized Bed Calcining System	2-19

LIST OF TABLES

Table Number		Page
2-1	TRS Emissions from An Uncontrolled 907 Megagrams (1,000 Tons) Per Day Kraft Pulp Mill	2-5
2-2	Typical Concentrations and Emission Rates For Particulate Matter From Uncontrolled Kraft Pulp Mill Sources	2-6
4-1	Design of Electrostatic Precipitators Subject to the NSPS	4-2
4-2	Particulate Emission Data for the No. 4 Recovery Furnace at the Tacoma, Washington, Mill, 1973 Through 1981	4-5
5-1	Compliance Test Results of Recovery Furnaces Subject to NSPS	5-2
5-2	Compliance Test Results of Smelt Dissolving Tanks Subject to NSPS	5-4
5-3	Compliance Test Results of Lime Kilns Subject to NSPS	5-6
6-1	Capital Costs, Annualized Costs, and Cost-Effectiveness	6-2

1. EXECUTIVE SUMMARY

The new source performance standards (NSPS) for kraft pulp mills were promulgated by the Environmental Protection Agency (EPA) on February 23, 1978. These standards affect recovery furnaces, smelt dissolving tanks, lime kilns, digester systems, multiple-effect evaporator systems, brown stock washer systems, black liquor oxidation systems, and condensate stripper systems. Affected facilities are those facilities which commenced construction or modification after September 24, 1976.

The objective of this report is to review the NSPS for kraft pulp mills, and to assess the need for revision on the basis of developments that have occurred since the original standard was promulgated. The following paragraphs summarize the results and conclusions of the analysis, as well as recommendations with respect to EPA action in implementing changes in the NSPS.

1.1 BEST DEMONSTRATED CONTROL TECHNOLOGY

The NSPS limits emissions of particulate matter and total reduced sulfur (TRS) compounds. The particulate sources covered are the recovery furnace, the smelt dissolving tank, and the lime kiln. These three facilities, along with power boilers, account for virtually all of the particulate matter emissions from a kraft pulp mill. Emissions of TRS are limited from eight affected facilities: the digester system, the brown stock washer system, the multiple-effect evaporator system, the black liquor oxidation system, the recovery furnace, the smelt dissolving tank, the lime kiln, and the condensate stripper system. These eight facilities account for virtually all of the TRS emissions from a kraft pulp mill.

No changes have occurred in the selection of control technologies used for either the particulate facilities or the TRS sources. The original particulate standards were based on the use of an electrostatic precipitator (ESP) for recovery furnaces, a venturi scrubber for lime kilns, and a wet scrubber for smelt dissolving tanks. These are the control devices installed on facilities subject to the NSPS. One ESP has been installed on a lime kiln. ESP's on lime kilns were investigated during the NSPS development, but were not used as the basis for the NSPS.

The original TRS standards were based on incineration of the noncondensable gas streams from the digesters, evaporators, washers, black liquor oxidation systems, and condensate strippers; type of water used for smelt dissolving tanks; process controls and either black liquor oxidation or noncontact evaporators for recovery furnaces; and process controls, good mud washing, and caustic scrubbing for lime kilns.

Most lime kilns subject to the NSPS have demonstrated compliance with the TRS standard without caustic addition. Presently, the mills are not required to continuously monitor the TRS emissions. Until continuous monitoring data are available, the ability of the present control systems to continuously achieve the TRS standard without caustic scrubbing cannot be determined.

Fluidized bed calciners subject to the NSPS have demonstrated compliance with both the particulate and TRS standards. Fluidized bed calciners are covered by the NSPS, but emission data demonstrating their performance were not included in the NSPS data base due to the limited use of fluidized bed calciners at the time of the NSPS development.

Compliance test results for facilities subject to the NSPS show that all are in compliance with the NSPS, except for two recovery furnaces and one smelt dissolving tank which have not been able to meet the TRS standard.

1.2 ECONOMIC CONSIDERATIONS AFFECTING THE NSPS

The capital and annualized costs for each control system were estimated during the NSPS development. During this review, those costs were updated to February 1982 using the Chemical Engineering plant cost index. In addition, the costs for the recovery furnaces were revised based upon information supplied by the companies on actual recovery furnace system operations. These updated and revised costs were compared with actual industry costs on control systems used to achieve the NSPS. For all cases for which actual industry data were available, the costs are similar.

The cost-effectiveness for each control system was estimated from the updated and revised costs and the emission reduction resulting from application of the control techniques. For each of the particulate control techniques, the incremental cost effectiveness over the economic recovery level was less

than $1,000 per ton. The cost effectiveness of the various TRS controls ranges from zero dollars per ton for the smelt dissolving tank to $9,250 per ton for the black liquor oxidation system. The brown stock washer system with a cost-effectiveness of $2,500 per ton is the only other affected facility with a cost effectiveness above $1,000 per ton. However, this cost was based on the use of a vacuum drum type washing system which was in general use during the NSPS development. Many of the washing systems subject to the NSPS are the diffusion types which are a closed reactor and have a much lower gas volume. Based on capital costs obtained from one mill, the cost effectiveness for control of diffusion type washers is estimated to be $900 per ton of TRS controlled.

Since the NSPS was proposed, 14 new recovery furnaces, 16 new smelt dissolving tanks, and 19 new lime kilns have started operation. The growth rate in terms of pulp production averaged 3.5 percent per year between 1978 and 1981. The forecast is for a 2.3 percent decline in overall industry production in 1982, but a 4.6 percent growth in 1983.

1.3 RECOMMENDATIONS ON REVISION OF CURRENT NSPS

There has been general compliance with the current NSPS with achievability of the existing standards adequately demonstrated. Based upon technological conclusions, it is recommended that the basis for the NSPS remain unchanged. It is recommended that the TRS standard for smelt dissolving tanks be raised to the level indicated by compliance data. It is also recommended that the units of the TRS standard for smelt dissolving tanks be revised to allow the use of EPA method 16A. It is recommended that the TRS standard for black liquor oxidation systems be rescinded. A revision is also recommended to rescind the requirement for monitoring the combustion temperature when a device other than an incinerator is used to destroy TRS emissions.

1.4 RECOMMENDATIONS ON EXTENSION TO THE NSPS

It is recommended that standards for other processes and pollutants not be considered at the present time. Recovery furnaces and lime kilns can be sources of nitrogen oxides, sulfur dioxide, and carbon monoxide, but control of these pollutants has not been demonstrated for the lime kiln and cost-effective control of sulfur dioxide emissions has not been demonstrated for recovery furnaces in the kraft pulp industry. It is recommended that a study be performed to investigate the sulfur dioxide emission control methods available for recovery furnaces and to determine whether regulation is appropriate.

Two sources of emissions not covered by the present NSPS are power boilers and treatment ponds. Power boilers will be regulated under standards being proposed for industrial boilers. Methods of measuring TRS emissions from water treatment ponds are not available.

2. THE KRAFT PULPING INDUSTRY

2.1 INTRODUCTION

The United States Environmental Protection Agency (EPA) proposed new source performance standards for kraft pulp mills under Section 111 of the Clean Air Act on September 24, 1976 (41 FR 42012). These regulations were promulgated on February 23, 1978 (43 FR 7568). The regulations applied to recovery furnaces, smelt dissolving tanks, lime kilns, digester systems, multiple-effect evaporator systems, black liquor oxidation systems, brown stock washer systems, and condensate stripper systems, the construction or modification of which commenced after September 24, 1976.

The Clean Air Act Amendments of 1977 require that the Administrator of the EPA review and, if appropriate, revise established standards of performance for new stationary sources at least every 4 years. The purpose of this report is to review and assess the need for revision of the existing standards for kraft pulp mills based on developments that have occurred or are expected to occur within the kraft pulping industry. The information presented in this report was obtained from reference literature, discussions with industry representatives, trade organizations, process and control equipment vendors, EPA regional offices, and State and local agencies.

2.2 BACKGROUND INFORMATION

Manufacturing of paper and paper products is a complex process which is carried out in two distinct phases: the pulping of the wood and the manufacture of the paper. Pulping is the conversion of fibrous wood into a "pulp" material suitable for use in paper, paperboard, and building materials. Of the two phases involved in paper-making, the pulping process is the largest source of air pollution. The kraft or sulfate pulping process produces over 80 percent of the chemical pulp produced annually in the United States. The remaining 20 percent of the chemical pulp is produced by the sulfite and neutral sulfite semi-chemical (NSSC) processes. These pulping processes were investigated as potential candidates for NSPS development in a 1978 study entitled "Screening Study on Feasibility of Standards

of Performance for Two Wood Pulping Processes." This study concluded that no new growth was predicted at that time and, therefore, an NSPS was not recommended to be developed.[1]

Pulp wood can be considered to have two basic components, cellulose and lignin. The fibers of cellulose, which comprise the pulp, are bound together in the wood by the lignin. To render cellulose usable for paper manufacture, the pulping process must first remove the lignin.

The kraft pulping process is shown in Figure 2-1. In the process, wood chips are cooked (digested) at an elevated temperature and pressure in "white liquor", which is a water solution of sodium sulfide (Na_2S) and sodium hydroxide (NaOH). The white liquor chemically dissolves lignin from the wood. The remaining cellulose (pulp) is filtered from the spent cooking liquor and washed with water. Usually, the pulp then proceeds through various intermittent stages of washing and possibly bleaching, after which it is pressed and dried into the finished product (paper).

The balance of the kraft process is designed to recover the cooking chemicals and heat. Spent cooking liquor and the pulp wash water are combined to form a weak black liquor which is concentrated in a multiple-effect evaporator system to about 55 percent solids. The black liquor is then further concentrated to 65 percent solids in a direct-contact evaporator, which evaporates water by bringing the liquor in contact with the flue gases from the recovery furnace, or in an indirect-contact concentrator. The strong black liquor is then fired in a recovery furnace. Combustion of the organics dissolved in the black liquor provides heat for generating process steam and converting sodium sulfate (Na_2SO_4) to Na_2S. To make up for chemicals lost in the operating cycle, salt cake (sodium sulfate) is usually added to the concentrated black liquor before it is sprayed into the furnace. Inorganic chemicals present in the black liquor collect as a molten smelt at the bottom of the furnace.

The smelt, consisting of sodium carbonate (Na_2CO_3) and sodium sulfide, is dissolved in water to form green liquor which is transferred to a causticizing tank where quicklime (CaO) is added to convert the sodium carbonate to sodium hydroxide. Formation of the sodium hydroxide completes the regeneration of white liquor, which is returned to the digester system. A calcium carbonate mud precipitates from the cauticizing tank and is calcined in a lime kiln to regenerate quicklime.

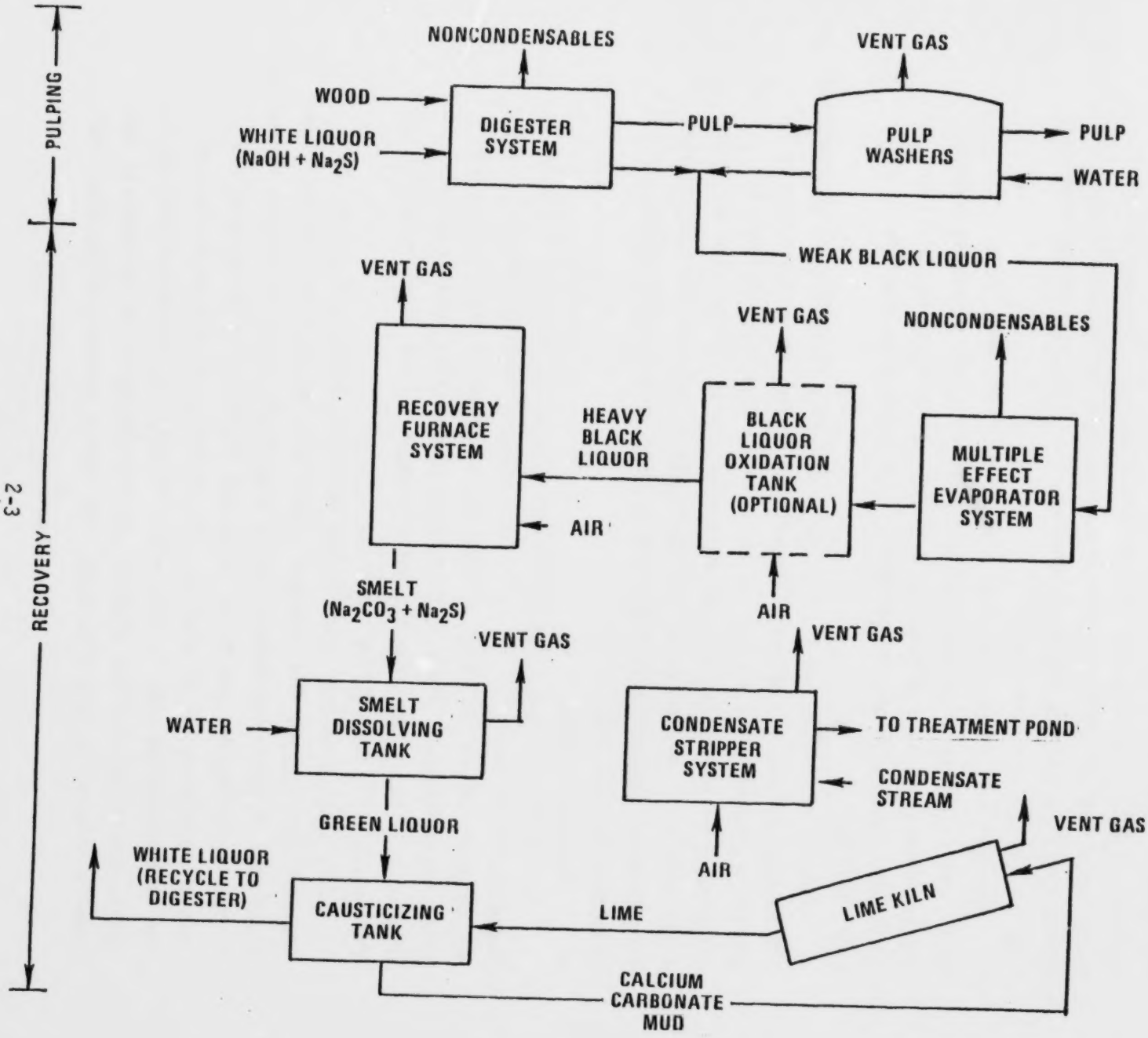


Figure 2-1. Kraft Pulping Process

2.3 DESCRIPTION OF INDIVIDUAL PROCESS FACILITIES AND THEIR EMISSIONS

The atmospheric emissions from the kraft process include both gaseous reduced sulfur compounds and particulate matter. The reduced sulfur compounds are hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3), and dimethyl disulfide (CH_3SSCH_3). The particulate matter emissions are primarily sodium sulfate from the recovery furnace, sodium salts and calcium compounds from the lime kiln, and sodium compounds from the smelt dissolving tank.

Hydrogen sulfide and the other organic sulfides, when taken as a group, are called total reduced sulfur (TRS). They are extremely odorous and are detectable at a concentration of only a few parts per billion. Thus, odor control is one of the principal air pollution problems in a kraft pulp mill.

Summaries of values on typical gas flow rates, variations in uncontrolled TRS concentrations, and uncontrolled emission rates per unit production for the kraft process units subject to the NSPS are presented in Table 2-1. These emission rates are for a 907 megagrams per day (1,000 tons per day) kraft pulp mill. A summary of typical ranges in uncontrolled particulate concentrations and emission rates from process units subject to the NSPS is presented in Table 2-2.

2.3.1 Digester System

In a digester, wood chips are cooked with white liquor at elevated temperatures of about 170° to 175°C and pressures ranging from 6.9 to 9.3 x 10^5 pascals (100 to 135 psig). There are two types of digester systems: batch and continuous. Most kraft pulping is presently done in batch digesters, although continuous digesters generally are being installed in the industry for new pulping capacity.

In a batch digester, gases formed during digestion are vented to "relieve" the digester and maintain proper cooking pressure. Relief takes place more or less continuously during digestion. At mills pulping turpentine-containing softwoods, the relief gases are first cooled to condense and recover turpentine before venting. The condenser cooling water recovers the heat and may be used in some other process. At the end of the cooking cycle, the contents of the digester are transferred to an atmospheric tank usually referred to as a blow tank. The entire contents of the blow tank

Table 2-1. TRS EMISSIONS FROM AN UNCONTROLLED 907 MEGAGRAMS (1,000 Tons) PER DAY KRAFT PULP MILL [2]

Source	Typical Exhaust Gas Flow Rate m^3/a(acfm)	TRS Emission Range		Average TRS Emission Rate	
		ppm	g/kg ADP (lb/T ADP)	ppm	g/kg ADP (lb/T ADP)
Recovery Furnace	212 (450,000)	18-1303	0.75-31 (1.5-62)	550	7.5 (15.0)
Digester System	3 (6,200)	1525-30,000	0.24-5.3 (0.47-10.5)	9,500	0.75 (1.5)
Multiple-Effect Evaporator System	1 (2,200)	92-44,000	0.015-3.2 (0.03-6.3)	6,700	0.5 (1.0)
Lime Kiln	37 (79,200)	3-613	0.01-2.1 (0.02-4.2)	170	0.4 (0.8)
Brown Stock Washer System	71 (150,000)	-	0.005-0.5 (0.01-0.9)	30	0.15 (0.3)
Black Liquor Oxidation System	14 (30,000)	3-335	0.005-0.37 (0.01-0.73)	35	0.05 (0.1)
Smelt Dissolving Tank	27 (58,100)	5-811	0.007-1.9 (0.013-3.70)	60	0.1 (0.2)
Condensate Stripper System	2 (4,000)	-	-	5,000	1.0 (2.0)

Table 2-2. TYPICAL CONCENTRATIONS AND EMISSION RATES FOR PARTICULATE MATTER FROM UNCONTROLLED KRAFT PULP MILL SOURCES[3,4]

	Concentration		Emission Rate	
	g/dscfm	(gr/dscf)	g/kg ADP	(lb/ton ADP)
Recovery Furnace	3.10-22.79	(1.35-9.95)	22.1-283	(44.1-565)
Lime Kiln	5.85-33.96	(2.44- 14.81)	6.4-49.9	(12.7-99.8)
Smelt Dissolving Tank	0.89-13.60	(0.39-5.94)	0.1-11.9	(0.19-23.7)

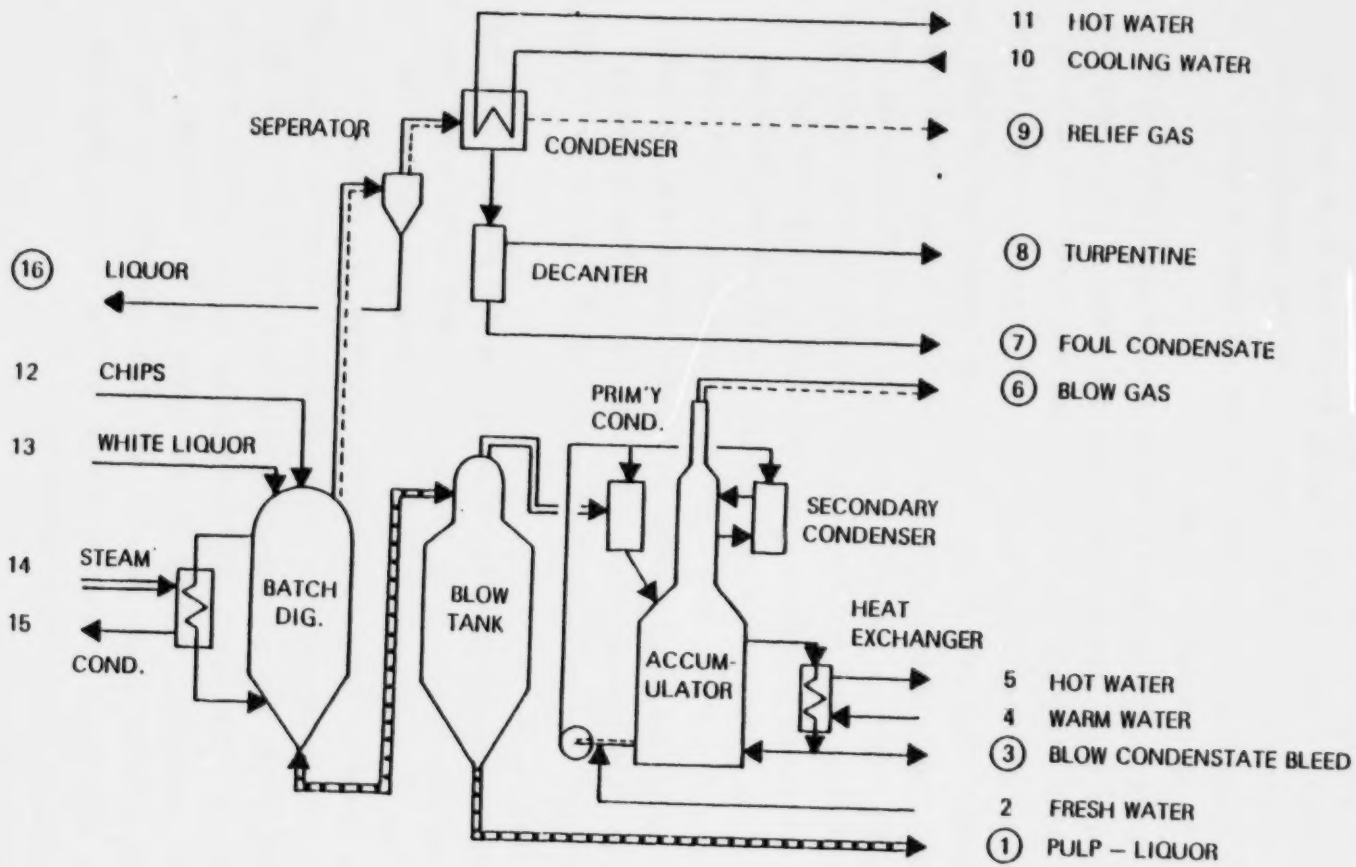
are normally sent to the pulp washers where the spent cooking liquor is separated from the pulp. Steam and other gases that flash from the blow tank are piped to a heat recovery unit. This blow of the digester is not applicable to continuous digester systems. Figure 2-2 shows a batch digester and its blow heat recovery system.

In a continuous digester, an uninterrupted flow of wood chips passes through the unit where steam and cooking liquor are added. Before entering the digester, the wood chips are fed to a pre-steaming vessel for wetting and deaeration. Most existing units have a countercurrent wash zone in the bottom of the digester. The wash liquor reduces the temperature of pulp-liquor mixture resulting in a so-called "cold blow". The spent liquor is drawn off and transferred to a flash tank where the liquor is expanded, or flashed. The flash steam from the flash tank is usually used to impregnate the chips in the pre-steaming vessel. The pre-steaming vessel relief, which contains the noncondensable gases from the flash tank and from the pre-steaming vessel, then passes to a condenser. When pulping softwoods, the condensate is separated in a decanter to recover turpentine. In some cases, a continuous diffusion washing stage (described in the following section) is integrated with the digester. A continuous digester arrangement is presented in Figure 2-3.

The noncondensable gases from the relief system and the blow tank vent contain TRS concentrations as high as 30,000 ppm.[4] Both streams are sometimes referred to as digester "noncondensables". TRS compounds formed in the digester are mainly methyl mercaptan, dimethyl sulfide, and dimethyl disulfide. Uncontrolled TRS emissions range between 0.24 and 5.25 g/kg ADP (0.5 and 10.5 lb/ton ADP) and average about 0.75 g/kg ADP (1.5 lb/ton ADP) at a concentration of 9,500 ppm.[4] Operating variables that affect digester TRS emissions and, therefore, account for the range of TRS emissions shown in Table 2-1 include black liquor recycle rate, cook duration, cooking liquor sulfidity (percentage of sodium sulfide to total alkali, Na_2S and NaOH, in white liquor), and residual alkali level.[5]

2.3.2 Brown Stock Washer System

Pulp from the digester system passes from the blow tank to the washing plant. The two main types of washers used for removal of black liquor are



Points of Possible Odor Release are Encircled by ○

Figure 2-2. BATCH DIGESTER FLOW SHEET[3]

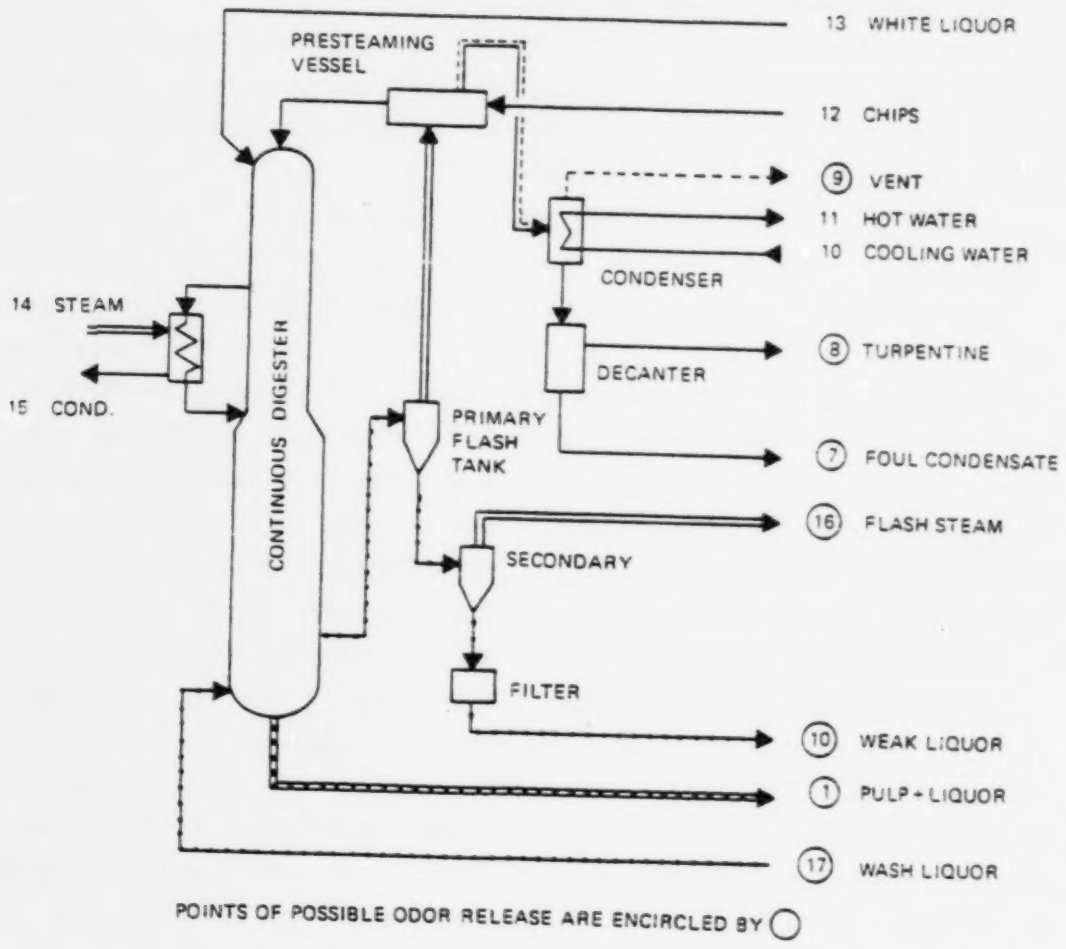


Figure 2-3. CONTINUOUS DIGESTER FLOW SHEET[3]

rotary-drum vacuum washers and diffusion washers. Vacuum washers are the most common type of kraft pulp washers, but diffusion washing is generally integrated with the continuous digesters used in newer mills.

In a vacuum washing system, the pulp first passes through the knotter which removes chunks of wood not digested during cooking. The pulp then is washed countercurrently with water in several sequential stages. On leaving each stage, the pulp is dewatered on a vacuum filter, and the water drains into filtrate tanks. The washers are normally hooded to collect the vapors that steam off the open washers.

Continuous diffusion washing usually takes place in a closed reactor. Figure 2-4 illustrates the unit. Inside the wall of the unit are pairs of cylindrical screen plates. Each pair of screen plates comprises a double-sided screen. Pulp enters the bottom of the unit and passes slowly upward between the screens. The wash medium, water, is introduced to the pulp by a set of nozzles. Each nozzle travels a circular path through the pulp, midway between adjacent screens. The wash water flows radially from each nozzle in both directions to the adjacent screens, thus displacing the chemical-laden water from the pulp. The extractant leaves the pulp via the perforations in the screen plates and flows downward to the drainage system. As the washed pulp rises above the screen section, it is removed by scrapers.

TRS emissions from the washers arise primarily from the vaporization of the volatile reduced sulfur compounds. TRS compounds emitted are principally dimethyl sulfide and dimethyl disulfide.[4] Uncontrolled TRS emissions from a vacuum drum washing system average about 0.14 g/kg ADP (0.27 lb/T ADP) at a concentration of 30 ppm. TRS emissions are affected by the wash water source, water temperature, degree of agitation and turbulence in the filtrate tank, and blow tank pulp consistency.[6] TRS emissions will increase significantly if contaminated condensate from the digester and evaporator systems is used for washing. Higher temperatures and agitation result in increased stripping of TRS during the washing.[5] TRS emission data for diffusion type washers are presently not available.

2.3.3 Multiple-Effect Evaporator System

Spent cooking liquor from the digester system is combined with the brown stock washer discharge to form weak (dilute) black liquor. Multiple-effect evaporators are utilized to concentrate the weak black liquor from

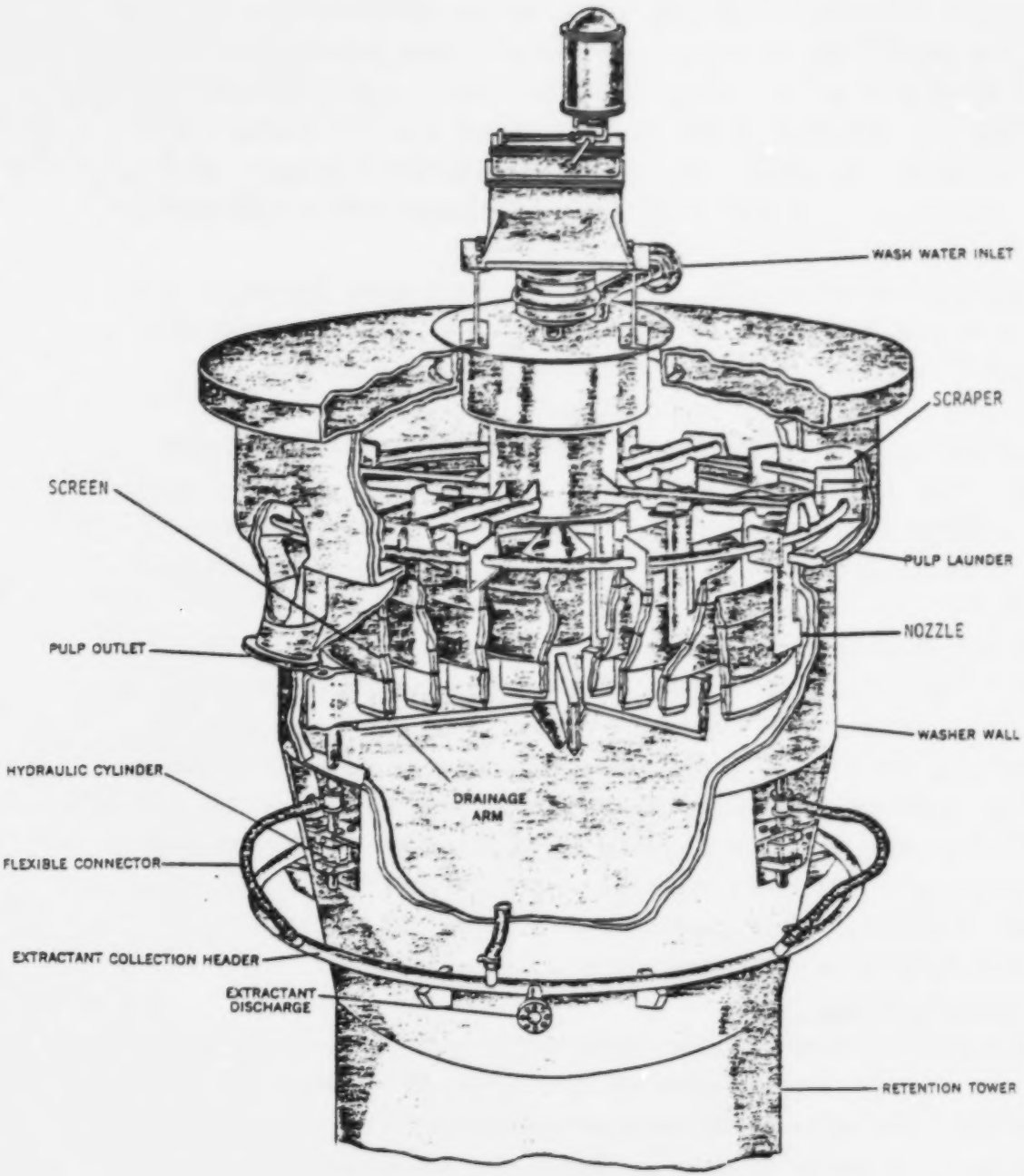


Figure 2-4. CONTINUOUS DIFFUSION WASHER[7]

an initial 12 to 18 percent solids to a final level of 40 to 55 percent solids. Concentration of the black liquor is necessary to facilitate combustion of the dissolved organic material in the recovery furnace. Usually, five or six evaporation units (effects) make up the system. Each effect consists of a vapor head and a heating element. Hot vapors from the vapor head of a previous effect pass to the heating element of the following effect. The effects are operated at successively lower pressures, which causes a decrease in the boiling point of the liquor. Vapors from the final effect are condensed rapidly enough to maintain a high vacuum. Two types of barometric condensers are used: direct contact condensers and surface condensers. Each type of condenser is equipped with a steam ejector to remove noncondensables.

The evaporation system will also contain concentrators for the final evaporation of black liquor to combustion strength if the associated recovery furnace is not equipped with a direct-contact evaporator.

The noncondensable gases from a multiple-effect evaporator system consist of air drawn in through system leaks and reduced sulfur compounds that were either in the dilute black liquor or formed during the evaporation process. TRS emissions are as high as 44,000 ppm.[4] Uncontrolled TRS emissions average about 0.5 g/kg ADP (1.0 lb/T ADP) at a concentration of 6,700 ppm.[4]

The type of condenser used can influence the concentration of TRS emissions. Certain types of condensers (e.g., direct-contact) allow the noncondensable gases and the condensing water to mix, which adds water to the condensates and results in more noncondensable gases being dissolved in this water, depending on the water temperature. This reduces the TRS emissions from the system, but increases the sulfide level in the condensate. Sulfidity and pH of the weak black liquor also have an effect on the TRS emissions. Higher sulfidity levels result in higher TRS emissions. TRS levels increase with decreasing pH levels.

2.3.4 Recovery Furnace System

The purposes of burning concentrated black liquor in the kraft recovery furnace are: (a) to recover sodium and sulfur, (b) to produce steam, and (c) to dispose of unwanted dissolved wood components in the liquor. In most instances, liquor of 60 to 65 percent solids content will burn in a self-supporting combustion.

The recovery furnace theoretically is divided into three sections: the drying zone, the reducing zone, and the oxidizing zone. The black liquor is introduced to the furnace through spray guns located in the drying zone. The heat in the furnace is sufficient to evaporate the remaining water from the liquor. The dried solids fall to the hearth to form the char bed.

Combustion of the black liquor char begins on the hearth of the furnace. Air for combustion is supplied by a forced-draft system to the reducing and oxidizing zones of the furnace. Since a reducing atmosphere is required to convert sodium sulfate and other sodium-based sulfur compounds to sodium sulfide, only a portion of the air required for complete combustion is supplied to the char bed through the lower or primary air ports. The heat released by the combustion in the zone is sufficient to liquefy the chemicals in the char and to sustain the endothermic reduction. The liquefied chemical, or molten smelt is continuously drained from the furnace hearth.

Air is admitted through secondary and tertiary air ports above the primary zone to complete the combustion of the volatile gases from the char in the furnace.

There are two main types of recovery furnace systems. The first type employs a direct-contact evaporator to provide the final stage of evaporation for the black liquor. This is accomplished by bringing the black liquor in direct contact with the furnace's exhaust gases. This furnace type is called a conventional or direct-contact system. A conventional system is shown in Figure 2-5. The second type of recovery furnace system employs an indirect-contact evaporator as the final evaporation stage; this type is called a noncontact, direct-fired, or "low odor" system. A noncontact system is shown in Figure 2-6. The majority of the furnace systems in operation are the conventional type, although newer installations tend to be noncontact recovery furnace systems.

In addition, so-called cross-recovery is practiced at several mills. In practice, the waste liquor from neutral sulfite semi-chemical (NSSC) cooking is combined with the black liquor from the kraft mill prior to burning. The inorganic content of the NSSC liquor will join the bulk of inorganics in the smelt from the furnace, substituting for the sodium sulfate normally added in the kraft recovery cycle to cover losses of chemicals.

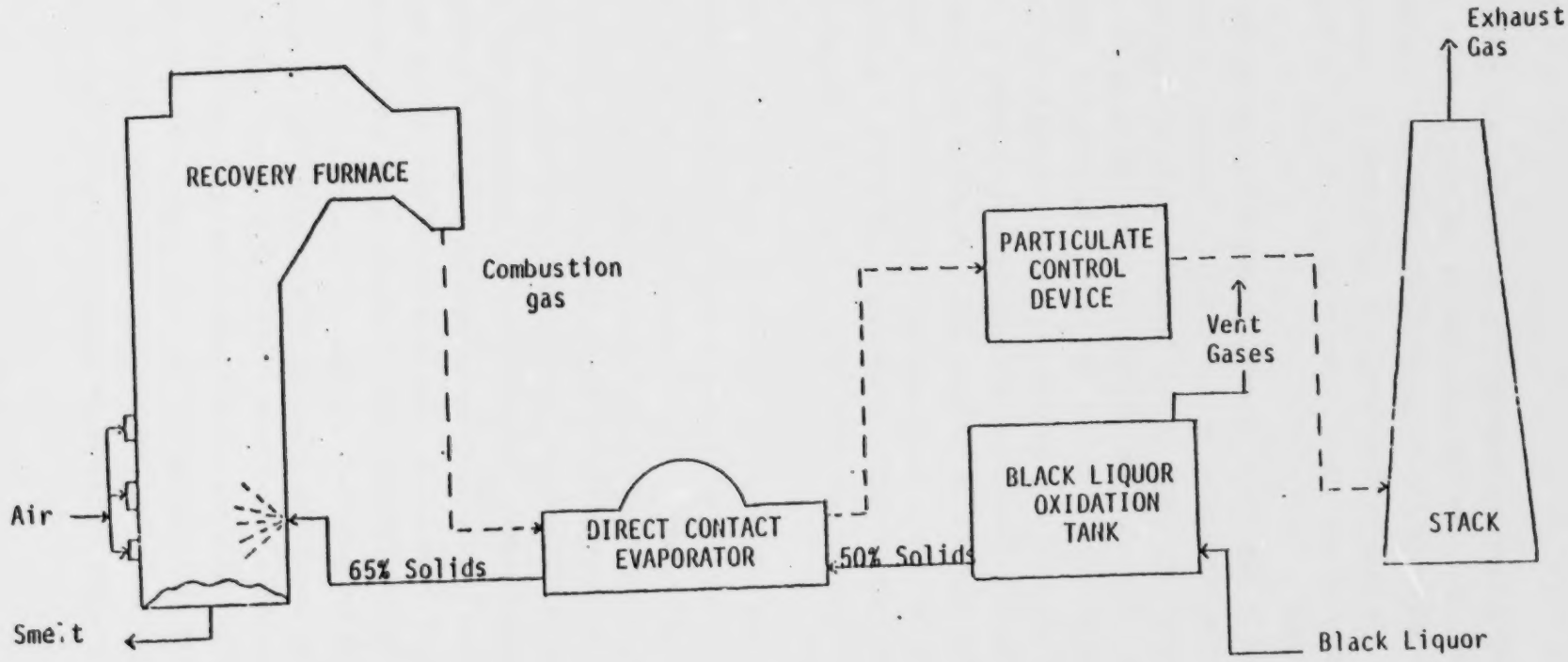


Figure 2-5. Direct Contact (Conventional) Recovery Furnace System With Black Liquor Oxidation

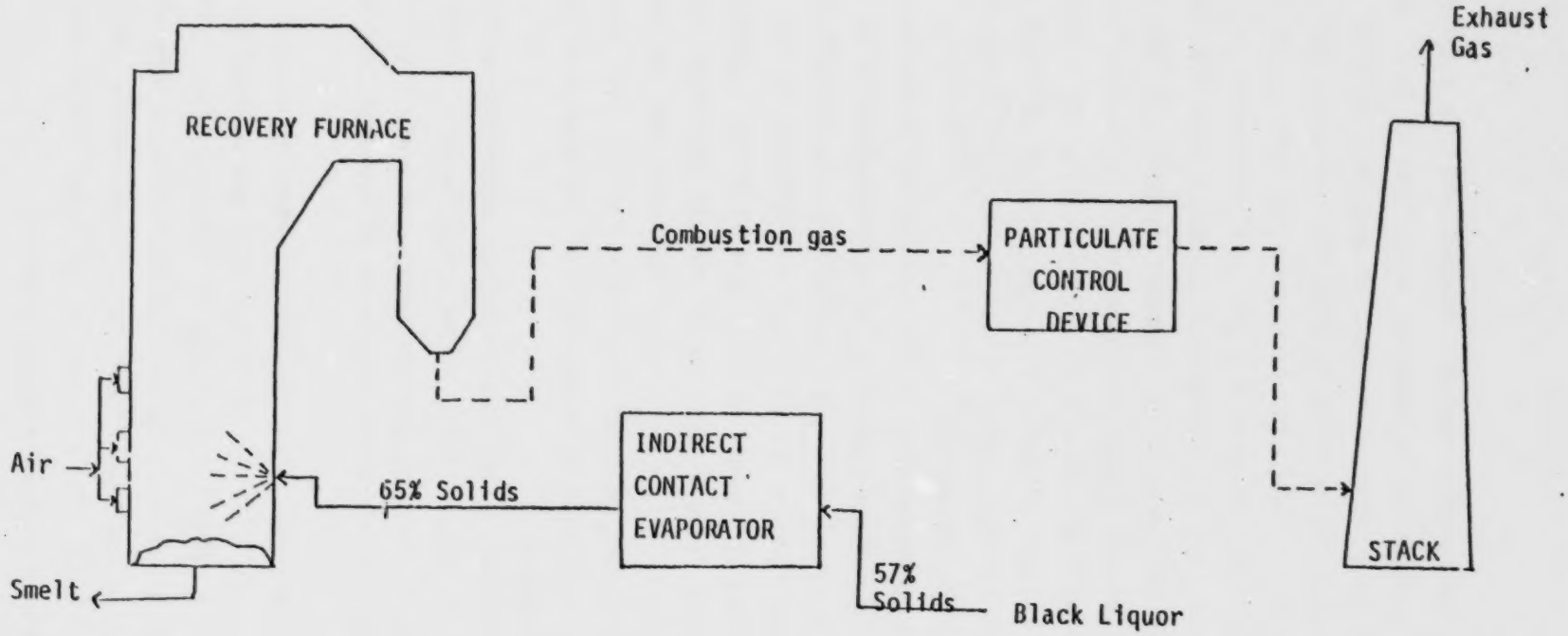


Figure 2-6. Indirect Contact Recovery Furnace System

The particulate levels from a recovery furnace prior to a direct-contact evaporator or control device normally range from 18 to 27 g/dscm (8 to 12 gr/dscf).[4] A direct-contact evaporator acts as a particulate control device and reduces the particulate emission from a furnace system by about 20 to 40 percent.[3] The particulate emissions from uncontrolled recovery furnace systems average about 8.7 g/dscm (3.8 gr/dscf, 180 lb/T ADP).[4] Data on particle size of uncontrolled emissions indicate that 90 percent of the particles from a direct-contact recovery furnace and 78 percent from a non-contact recovery furnace are 10 μm or less in size.[8] The particulate matter emitted consists of sodium sulfate and sodium carbonate and may contain small amounts of sodium chloride. Sodium chloride will be present if the pulpwood has been stored in saline water or if the make-up chemicals contain chloride impurities.

TRS emissions are generated both in the furnace and in the direct-contact evaporator. The furnace-generated TRS concentration is as high as several hundred ppm and as low as 1 ppm, depending on the furnace design and operation. Recovery furnace TRS emissions are affected by the relative quantity and distribution of combustion air, rate of solids (concentrated black liquor) feed, spray pattern and droplet size of the liquor fed, turbulence in the oxidation zone, smelt bed disturbance, and the combination of sulfidity and heat content value of the liquor fed.[2,4] The impact of these variables on TRS emissions is independent of the absence or presence of a direct-contact evaporator.[4]

TRS emissions generated in the direct-contact evaporator depend largely on the concentration of sodium sulfide in the black liquor. Acidic gases such as carbon dixoide in the flue gas can change the black liquor equilibrium, resulting in the release of increased quantities of hydrogen sulfide and methyl mercaptan.

Uncontrolled TRS emissions from conventional recovery furnace systems range from 0.75 to 31 g/kg ADP (1.5 to 62 lb/T ADP) and average about 7.5 g/kg ADP (15 lb/T ADP).[4] This is an average of about 550 ppm. TRS emissions from uncontrolled indirect-contact furnace systems would be somewhat less because these furnaces do not have direct-contact evaporators (which can contribute up to 15 g/kg ADP [30 lb/T ADP] of the total uncontrolled TRS emissions shown for direct-contact furnace systems[3]).

2.3.5 Smelt Dissolving Tank

The smelt dissolver is a large tank located below the recovery furnace hearth. Molten smelt (sodium carbonate and sodium sulfide) that accumulates on the floor of the furnace is dissolved in water to form green liquor in the tank. The tank is equipped with an agitator to assist dissolution, and a steam or liquid shatterjet system to break up the smelt stream before it enters the solution. Contact of the molten smelt with the water causes the evolution of large volumes of steam, which must be vented.

The sodium carbonate (Na_2CO_3) in the green liquor is converted to sodium hydroxide (NaOH) in the causticizing tank. This is done by adding quicklime (CaO) to the liquor. The quicklime forms calcium hydroxide, $Ca(OH)_2$, which reacts with Na_2CO_3; calcium carbonate precipitates out and is converted back into quicklime in a lime kiln.

Particulate matter (finely divided smelt) is entrained in the vapor that leaves the tank. Uncontrolled emissions may be as high as 4 g/kg ADP (8 lb/T ADP).[4] Twenty-four percent of the particles from an uncontrolled smelt dissolving tank are 10 μm or less in size.[8]

Because of the presence of a small percentage of reduced sulfur compounds in the smelt, some of these odorous materials escape the tank with the flashed steam. Uncontrolled TRS emissions are as high as 2.0 g/kg ADP (811 ppm) and as low as nondetectable.[4] The average is about 0.1 g/kg ADP (0.05 lb/T ADP).

Several factors affect the TRS emissions. Among these are the water used in the smelt tank, turbulence of the dissolving water, scrubbing liquor used in the particulate control device, pH of the scrubbing liquor, and sulfide content of the particulate collected in the control device.[6] The use of contaminated condensate in the smelt tank or the scrubber can result in the stripping of TRS compounds into the gas stream.

2.3.6 Lime Kiln

The lime kiln is an essential element of the closed-loop system that converts green liquor (solution of sodium carbonate and sodium sulfide) to white liquor. The kiln calcines the lime mud (calcium carbonate which precipitates from the causticizer) to produce calcium oxide (quicklime, CaO). The quicklime is wetted (slaked) by the water in the green liquor solution to form calcium hydroxide, $Ca(OH)_2$, for the causticizing reaction.

The kraft pulp industry typically uses large rotary kilns that are capable of producing 36 to 360 megagrams (40 to 400 tons) of quicklime per day. Lime mud is fed in at the elevated end as a 55 to 60 percent solid-water slurry. The mud is contacted by hot gases produced by the combustion of natural gas or fuel oil and proceeding through the kiln in the opposite direction. Large motors turn the entire kiln at low speeds (1-2 rpm), causing the lime to proceed downward through the kiln toward the high-temperature zone (980 to 1090°C; 1800 to 2000°F) to discharge at the lower end. As the mud moves along, it dries in the upper section, which may be equipped with chains or baffles to give the wet mud better contact with the gases. As the lime mud moves down farther, it agglomerates into small pellets and finally is calcined to calcium oxide in the high-temperature zone near the burner. Some of the rotary lime kilns recently installed have been equipped with tube coolers for heat recovery.

Fluidized bed kiln systems have found limited application in the kraft pulping industry. Figure 2-7 shows a fluidized bed system. The system is divided into two basic parts: the drying system in which the mud is dried to form dry, powdery feed for the calciner, and the calcining system which produces the lime. The lime mud is fed to a cage mill disintegrator along with calciner stack gases. The dried powder is swept upward in the gas stream to a cyclone collection system. The dry powder collected in the cyclones is discharged to a storage bin which feeds the calciner. Calcination takes place in a two compartment reactor. The upper fluid bed is used for calcination and the lower fluid bed cools the calcined product. A positive displacement type blower is used to supply air to the reactor for fluidization, which also serves as combustion air for fuel burning.

Particulate emissions consist principally of sodium salts, calcium carbonate, and calcium oxide. The sodium salt emission results primarily from sodium compounds that are retained in the lime mud because of less efficient or incomplete washing. The calcium particles result from entrainment. Uncontrolled particulate emissions average about 40 g/kg ADP (80 lb/T ADP) at a concentration of 22.2 g/dscm (9.7 gr/dscf).[4] Data on particle size indicate that 25 percent of the particles from an uncontrolled lime kiln are 10 μm or less in size.[8]

TRS emissions can be generated in the lime kiln proper and may also be released from the liquor in the downstream scrubber which is normally

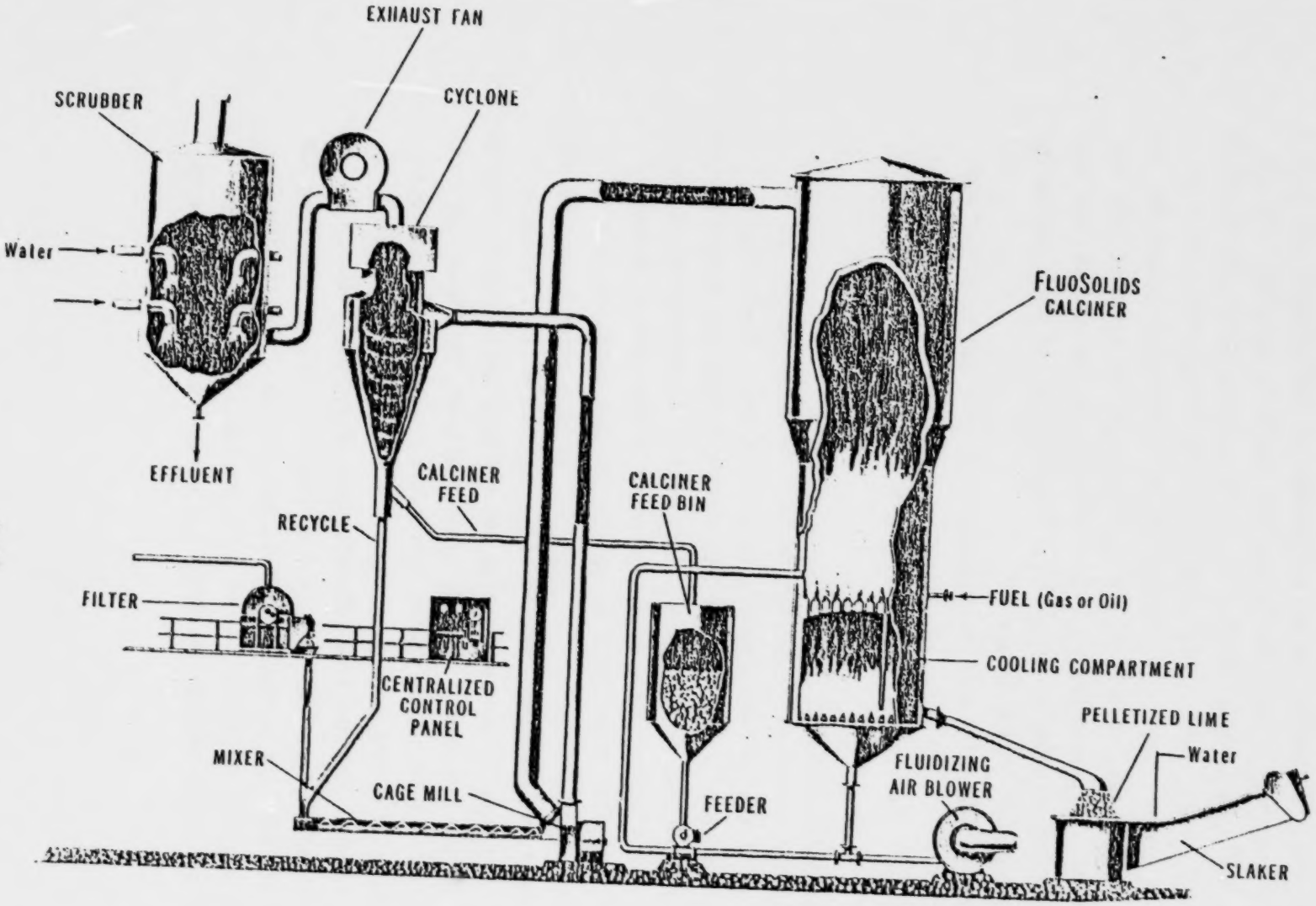


Figure 2-7. FLUIDIZED BED CALCINING SYSTEM[8]

installed to control particulate emissions. TRS emissions originating in the lime kiln are affected by the oxygen content of the exhaust, the kiln length to diameter ratio, the lime mud sulfide content, cold-end exit gas temperature, and simultaneous burning of sulfur bearing materials contained in the lime mud (e.g., green liquor dregs, the impurities resulting from clarifying the green liquor).[10] If digester and evaporator condensates are used as scrubbing water, reduced sulfur compounds can be stripped into the exit gas stream. If the scrubbing liquor contains sodium sulfide, H_2S may be released in the scrubber as a result of the equilibrium shift caused by the absorption of CO_2 in the liquor.

Uncontrolled TRS emissions average about 0.4 g/kg ADP (0.8 lb/T ADP) at a concentration of 170 ppm. TRS emissions range between 3 and 600 ppm (0.02 to 4.2 lb/T ADP) depending on combustion characteristics of the individual kilns.[4]

2.3.7 Black Liquor Oxidation System

Black liquor oxidation is applied to facilitate the control of TRS emissions from direct contact recovery furnace systems. Black liquor oxidation is designed to decrease the TRS emissions from the direct contact evaporator by producing a negligible sodium sulfide concentration in the black liquor by oxidizing the sodium sulfide in either weak or strong black liquor to sodium thiosulfate or possibly higher oxidation states. In those mills which oxidize black liquor, air is most often used. However, molecular oxygen has been used instead of air at some mills. Sparging reactors, packed towers, and bubble tray columns have been used in singular or multiple stages to provide intimate contact between the liquor and air.

TRS emissions from the oxidation system are created by the stripping of the reduced sulfur compounds from the black liquor by passing air through the liquor. Uncontrolled TRS emissions (principally dimethyl sulfide and dimethyl disulfide) are in the range of 0.005 to 0.37 g/kg ADP (about 3 to 335 ppm) and average 0.05 g/kg ADP (35 ppm).[4] Oxidation systems that use only molecular oxygen have the advantage of emitting virtually no off-gases because the total gas stream reacts in the sparge system.

2.3.8 Condensate Stripping System

When digester and multiple-effect evaporator off-gases are condensed, some TRS gases are partially dissolved in the condensate. To prevent the release of kraft odor (TRS) from either the recycled water or the water treatment ponds, the TRS compounds can be stripped from the digester and multiple-effect evaporator condensates prior to being recycled or discharged to the ponds. The two principal ways of stripping are air stripping and steam stripping. Stripping can be performed in multistage (multiple tray) columns with a large countercurrent flow of air or steam.

Actual TRS emission data are unavailable, but TRS emissions from condensate strippers are expected to be high because the condensate contains high concentrations of dissolved TRS compounds. Uncontrolled TRS emissions are estimated to range from 0.3 to 5.2 g/kg ADP (0.15 to 2.6 lb/T ADP) and average 0.6 g/kg ADP (1.1 lb/T ADP, 2,800 ppm).[11]

2.4 INDUSTRY CHARACTERIZATION

There are approximately 121 existing kraft pulp mills operating in the United States. The locations of these mills are distributed among 28 States, with the Southeast, Northwest, and Northeast being the areas of greatest density.

The main product of the kraft pulping industry is wood cellulose or pulp. About 35,894,000 megagrams (39,574,000 tons) of kraft pulp were produced in 1981.[12] The first quarter 1982 market price for bleached kraft pulp was 474 to 518 dollars per air dried megagram (430 to 470 dollars per air dried ton).[13]

Between 1956 and 1975, the growth rate of the industry was 5.5 percent per year. The growth rate averaged 3.5 percent per year between 1978 and 1981. The forecast is for a 2.3 percent decline in overall industry production for 1982 and a 4.6 percent growth in 1983.[13]

2.5 SELECTION OF KRAFT PULP MILL FOR NSPS CONTROL

Kraft pulp mills were originally selected for NSPS development because they can be significant sources of total reduced sulfur (TRS) compounds and particulate matter. At the time of NSPS development, the nationwide emissions of TRS exceeded 181,000 megagrams (200,000 tons) in 1973; emissions of particulate matter totaled 363,000 megagrams (400,000 tons) during the same year. The growth rate was projected to be 2.5 percent per year

between 1975 and 1978, with a return to a higher rate by 1980.[14] As stated above, the actual growth rate between 1978 and 1981 was 3.5 percent per year.

2.6 REFERENCES

1. Screening Study on Feasibility of Standards of Performance for Two Wood Pulping Processes, U.S. Environmental Protection Agency, Publication No. EPA-450/3-78-111, November 1978.

2. Kraft Pulping - Control of TRS Emissions from Existing Mills, U.S. Environmental Protection Agency, Publication No. EPA-450/2-78-003b, March 1979.

3. Environmental Pollution Control--Pulp and Paper Industry, Part I Air, U.S. Environmental Protection Agency, EPA-625/7-76-001, October 1976.

4. Atmospheric Emissions from the Pulp and Paper Manufacturing Industry, EPA-450/1-73-002, September 1973. (Also published by NCASI as Technical Bulletin No. 69, February 1974).

5. Control of Atmospheric Emissions in the Wood Pulping Industry, Volume I, Environmental Engineering, Inc., Gainesville, Florida, and J.E. Sirrine Company, Greenville, South Carolina, Contract No. CPA 22-69-18, March 1970.

6. Factors Affecting Emission of Odorous Reduced Sulfur Compounds from Miscellaneous Kraft Process Sources, NCASI Technical Bulletin No. 60, March 1972.

7. Kamyr Continuous Diffusion Washer, Kamyr Inc., Glens Falls, New York, Bulletin No. 600.

8. Particulate Mass and Particle Size Measurements at Representative Kraft Pulp Mills, Volume 1 (Draft), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, January 1982.

9. Dorr-Oliver Fluosolids System For Lime Mud Reburning in Connection with Recausticizing in Kraft Mills, Dorr-Oliver Incorporated, Stamford, Connecticut, Bulletin No. 7550-F.

10. Suggested Procedures for the Conduct of Lime Kiln Studies to Define Emissions of Reduced Sulfur Through Control of Kiln and Scrubbing Operating Variables, NCASI Special Report No. 70-71, January 1971.

11. Contaminated Condensate Stripping--An Industry Survey, McCance, K.E. and Burke, H.G., Pulp and Paper Canada, Vol 81, No. 11, November 1980.

12. Paper Trade Journal, April 30, 1982.

13. Paper Trade Journal, May 30, 1982.

14. Standards Support and Environmental Impact Statement, Volume 1: Proposed Standards of Performance for Kraft Pulp Mills, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, Publication No. EPA-450/2-76-014a, September 1976.

3. CURRENT STANDARDS FOR KRAFT PULP MILLS

3.1 AFFECTED FACILITIES

The existing new source performance standards (NSPS) for new, modified, and reconstructed kraft pulp mills limit emissions from recovery furnaces, smelt dissolving tanks, lime kilns, digester systems, multiple-effect evaporator systems, black liquor oxidation systems, brown stock washer systems, and condensate stripping systems. The standards governing recovery furnaces apply to both straight kraft recovery furnaces and cross recovery furnaces.

3.2 CONTROLLED POLLUTANTS AND EMISSION LEVELS

The NSPS limits emissions of total reduced sulfur (TRS) and particulate matter. The standards are as follows:

Particulate Matter

° Recovery furnace--Exhaust gases discharged into the atmosphere shall not contain particulate matter in excess of 0.10 g/dscm (0.044 gr/dscf) corrected to 8 percent oxygen, and shall not exhibit 35 percent opacity or greater.

° Smelt dissolving tank--Exhaust gases discharged into the atmosphere shall not contain particulate matter in excess of 0.1 g/kg black liquor solids (dry weight) [0.2 lb/ton black liquor solids (dry weight)].

° Lime kiln--Exhaust gases discharged into the atmosphere shall not contain particulate matter in excess of:

a) 0.15 g/dscm (0.067 gr/dscf) corrected to 10 percent oxygen, when gaseous fossil fuel is burned.

b) 0.30 g/dscm (0.13 gr/dscf) corrected to 10 percent oxygen, when liquid fossil fuel is burned.

TRS

° Straight kraft recovery furnace--Gases discharged into the atmosphere shall not contain TRS in excess of 5 ppm by volume on a dry basis, corrected to 8 percent oxygen.

° Cross recovery furnace--Gases discharged into the atmosphere shall not contain TRS in excess of 25 ppm by volume on a dry basis, corrected to 8 percent oxygen.

° Smelt dissolving tank--Gases discharged into the atmosphere shall not contain TRS in excess of 0.0084 g/kg black liquor solids (dry weight) [0.0168 lb/ton black liquor solids (dry weight)].

° Lime kiln--Gases discharged into the atmosphere shall not contain TRS in excess of 8 ppm by volume on a dry basis, corrected to 10 percent oxygen.

° Digester system, brown stock washer system, multiple-effect evaporator system, black liquor oxidation system, or condensate stripper system--Gases discharged shall not contain TRS in excess of 5 ppm by volume on a dry basis, corrected to 10 percent oxygen.

3.3 NSPS IMPACT ON EXISTING KRAFT PULP MILLS

The Clean Air Act applies to three general categories of pollutants emitted from stationary sources. These are criteria pollutants, hazardous pollutants, and designated pollutants. At existing sources, the first two categories can be controlled under Sections 108-110, or 112 of the Act. The third category consists of pollutants that are (or may be) harmful to public health or welfare but are not or cannot be controlled under Sections 108-110 or 112. Section 111(d) requires control of existing sources of such pollutants whenever standards of performance (for those pollutants) are established under Section 111 for new sources of the same type. The NSPS developed and promulgated for kraft pulp mills include emission limits for TRS and particulates. TRS is a designated pollutant and, therefore, under Section 111(d), States are required to develop TRS emission standards for the affected facilities. Since the EPA determined that TRS emissions will be considered a welfare-related pollutant, States have greater flexibility in establishing plans for the control of TRS.

3.4 STATE REGULATIONS

A survey was conducted of current State air quality regulations controlling kraft pulp mills. State standards governing particulate matter from existing kraft mills are generally less stringent than the Federal NSPS. State opacity standards are, however, similar to the NSPS. State regulations for

TRS emissions have been developed in accordance with Section 111(d) of the Clean Air Act. The State standards are generally similar to the 111(d) guidelines, which are identical to the NSPS except that no control is required for BLO systems and brown stock washer systems, and the TRS level for lime kilns is 20 ppm instead of 8 ppm.

3.5 TESTING AND MONITORING REQUIREMENTS

3.5.1 Testing Requirements

Performance tests to verify compliance with the particulate and TRS standards for the affected facilities must be conducted within 60 days after achieving full capacity operation, but not later than 180 days after the initial startup of the facility (40 CFR 60.8). The EPA reference methods to be used in connection with the affected facilities include:

1. Method 5 for the concentration of particulate matter and the associated moisture content.
2. Method 1 for sample and velocity traverses.
3. Method 3 for gas analysis.
4. Method 9 for visible emissions.
5. Method 16 for the concentration of TRS.

For Method 5, the sampling time for each run is at least 60 minutes with a minimum sampling rate of 0.85 dscm/hr (0.53 dscf/min). Water is used as the cleanup solvent instead of acetone in the sample recovery procedure outlined in Method 5.

When determining compliance for the smelt dissolving tank, Method 2, for velocity and volumetric flow rate, and the black liquor solids feed rate are also used. The following equation is used to determine the TRS emission rate:

$$E = (C_{H_2S}F_{H_2S} + C_{MeSH}F_{MeSH} + C_{DMS}F_{DMS} + C_{DMDS}F_{DMDS})\ (Q_{Sd})\ /\ BLS$$

where: E = mass of TRS emitted per unit of black liquor solids (g/Kg)

C_{H_2S} = average concentration of hydrogen sulfide (H_2S), ppm

C_{MeSH} = average concentration of methyl mercaptan (MeSH), ppm

C_{DMS} = average concentration of dimethyl sulfide (DMS), ppm

C_{DMDS} = average concentration of dimethyl disulfide (DMDS), ppm

F_{H_2S} = 0.001417 g/(m^3 ppm)

F_{MeSH} = 0.00200 g/(m^3 ppm)

F_{DMS} = 0.002583 g/(m^3 ppm)
F_{DMDS} = 0.003917 g/(m^3 ppm)
Q_{sd} = standard dry volumetric stack gas flow rate (dscm/hr)
BLS = black liquor solids feed rate, kg/hr

Method 17 (in-stack filtration) may be used as an alternate method for Method 5 for determining compliance with the NSPS, provided that a constant value of 0.009 g/dscm (0.004 gr/dscf) is added to the results of Method 17 and the stack temperature is no greater than 205°C (400°F). Water is also used as the cleanup solvent in the sample recovery procedure instead of acetone, which is outlined in Method 17.

Method 16A (Impinger Technique) has been proposed as an alternative method for Method 16 for determining compliance with the NSPS. This method utilizes the impinger collection method and barium-thorin titration producer outlined in EPA Method 6. Method 16A measures all reduced sulfur in contrast to the four reduced sulfur compounds specified in Method 16. Therefore, Method 16A may give higher results than Method 16, but the EPA expects any difference to be insignificant.

All concentrations of particulate matter and TRS resulting from these measurements are corrected to 10 volume percent oxygen for lime kilns and to 8 volume percent oxygen for recovery furnaces.

3.5.2 Monitoring Requirements

A continuous monitoring system is required to monitor and record the opacity of gases discharged into the atmosphere from the recovery furnace. For lime kilns and smelt dissolving tanks using a scrubber, a monitoring device is required for the continuous measurement of the pressure loss of the gas stream through the scrubber and of the scrubbing liquid supply pressure to the scrubber.

Continuous monitoring systems are required under the NSPS to monitor and record the concentration of TRS emissions on a dry basis and the percent of oxygen by volume on a dry basis in the gases discharged from recovery furnaces and lime kilns. However, the TRS monitoring system requirement will not be effected until performance specifications for the monitoring system are promulgated. The performance specifications were proposed on July 20, 1981 (46 CFR 37287).

A monitoring device which measures the combustion temperature at the point of incineration is required for the noncondensable gas streams from the digester system, multiple-effect evaporator system, brown stock washer system, black liquor oxidation system, and condensate stripper system. A temperature monitor is not required if the incineration device is a lime kiln or recovery furnace subject to the NSPS.

4. STATUS OF CONTROL TECHNOLOGY

The methods of emission control being employed on process facilities subject to the NSPS are presented in this chapter. A comparison is also presented between these control systems and the control systems which were used as a basis for the NSPS. In general, the control equipment being used by the industry is that upon which the data base for the NSPS was developed. To develop this information, the EPA contacted kraft pulp mills, State agencies, and EPA Regional offices.

4.1 PARTICULATE CONTROL

4.1.1 Recovery Furnace

All recovery furnaces subject to the NSPS employ electrostatic precipitators (ESP) as their particulate control devices. The ESP has been extensively used in the kraft pulp industry. Initially, ESP's were primarily installed for recovery of the soda ash suspended in the recovery furnace flue gas for economic purposes.

Both direct contact and non-contact type furnaces have been installed under the NSPS. The physical arrangements and design details of ESP's installed to control emissions from recovery furnaces subject to the NSPS are presented in Table 4-1. ESP's installed to control particulates from non-contact furnaces tend to be larger than ESP's on direct contact furnaces because of the higher inlet loadings and finer and lower density dust associated with non-contact furnaces. Although the purpose of the direct contact evaporator is to concentrate black liquor, it may also remove up to 50 percent of the particulate matter from the gas stream. The collector plate area to air flow ratios or SCA's (square feet of plate area per 1,000 cubic feet per minute of gas volume) reported for ESP's on non-contact furnaces range from 438 to 587 and average 500. The only reported SCA for a direct contact system is 453. These design SCA values are higher than the design SCA values of the ESP's tested by the EPA during the NSPS development program. The design SCA values for the EPA-tested ESP's ranged from 346 to 441 and averaged 374 for direct contact systems and 412 for non-contact systems.

Table 4-1. Design of Electrostatic Precipitators Subject to the NSPS[1-11]

ESP	Furnace Type Controlled[a]	Physical Arrangement					Design Parameters				
		Bottom Type	Wire Type	Shell Type	No. of Chambers	No. of TR Sets	SCA	Air Velocity (ft/s)	Efficiency (%)	Power Input kVA/1000cfm	Current Input mA/1000cfm
A	NC	Wet	Weighted	Heated	2	12	478	2.5	99.8	1.9	22.2
B	DC	Wet	Weighted	Heated	3	9	453	3.2	99.8	2.5	--
C	NC	Wet	Weighted	Heated	2	14	587	3.3	99.8	3.5	34.3
D	DC	Wet	Rigid	Heated	2	6	--	--	99.7	2.2	--
F	NC	Wet	--	--	2	10	--	--	--	--	--
G	NC	Dry	--	--	2	6	461	3.2	99.7	--	--
H	NC	Dry	Rigid	Insulated	2	8	438	2.84	99.7	2.8	33.4
I	NC	Dry	Weighted	Heated	2	8	510	3.3	99.8	2.4	31.2
P	NC	Dry	Weighted	Heated	2	12	542	2.7	99.8	--	--
Q	NC	Wet	Weighted	Heated	2	6	506	2.0	99.7	--	--
S	NC	Wet	Rigid	Heated	2	8	472	3.8	99.7	--	--

[a] NC = Non-contact type
DC = Direct contact type

In 1979, the Technical Association of the Pulp and Paper Industry (TAPPI) Air Committee conducted surveys on electrostatic precipitators used to control emissions from direct contact furnaces and non-contact furnaces.[8,9,10] The surveys reviewed new facilities which started up between 1973 and 1977 for direct contact furnaces and 1974 and 1978 for non-contact furnaces, and presented the design and performance results of a second generation of salt cake electrostatic precipitators.

The 1979 surveys indicate:[12-14]

° The industry has made significant progress in the control of particulate matter from recovery furnaces.

° The heated steel shell design ESP has displaced the tile shell design.

° An ESP for application to non-contact furnaces require about 40 percent more SCA than ESP's on similar direct contact furnaces.

° Maintenance costs for ESP's applied to direct contact furnaces are about $38,000/year compared to costs of about $76,000/year for ESP's applicable to non-contact furnaces.

° Problems, as reported in the 1974 survey, of salt cake buildup on rappers, inlet vane pluggage, damper problems, unit undersizing, and "snowing" (the emission of large white particles resembling snowflakes) have been solved.

° The newer ESP installations on non-contact furnaces have higher reliability and higher particulate removal efficiencies.

° Wet-bottom ESP's have a significant reduction in yearly downtime over dry-bottom ESP's.

During this review, EPA personnel visited five kraft mills, contacted four EPA regional offices, several State agencies, and sent information requests to eight mills. The result of these contacts generally confirmed the 1979 study results, except that the ESP's on non-contact furnaces subject to the NSPS have about 15 percent, instead of 40 percent, more SCA than ESP's on direct contact furnaces subject to the NSPS.

During the NSPS development program, the industry voiced concerns about the potential for gradual ESP deterioration and potential maintenance problems.

Concerning the problem of gradual deterioration of precipitator performance, the St. Regis' Tacoma, Washington, mill, which was tested as part of the NSPS development program, was contacted to obtain information on maintenance costs and ESP performance.[15] The recovery furnace and ESP started operation in 1973. The result of the EPA test conducted in 1974 was 0.003 gr/dscf (0.007 g/dscm).[16] The result of the latest quarterly test (September 1982) reported to the State agency was 0.034 gr/dscf (0.081 g/dscm), corrected to 8 percent oxygen.[17] Table 4-2 presents the results of monthly and quarterly testing done by the company for the ESP since startup in 1973 through September 1982. The data reported for the period from startup to December 1980 were collected using the Washington State sampling train, which includes both the front and back half fractions. The NSPS is, however, based only on the front half fraction which, based on the EPA test at St. Regis, is less than half of the total sampling train result. Starting in March 1981, only the front half fraction is reported. The data shown in Table 4-2 indicate that, with maintenance, the ESP is still capable of achieving the NSPS level after 9 years of operation. The main maintenance problems for the St. Regis' dry-bottom ESP have been with the rappers and the screw conveyors. Total maintenance for the unit has averaged 913 manhours over a five year period (1977-1981). This mill has also reported no corrosion problems with this 9-year-old ESP. Information obtained from mills with furnaces subject to the NSPS indicate no major operating or maintenance problems. Maintenance is usually performed on an "as needed" basis since the mills have the ability to isolate either chamber of the ESP without shutting down the furnace operation. Physical inspection of the ESP's are generally conducted once or twice per year when the mill is shutdown for general maintenance. These units subject to the NSPS have generally been in operation less than 3 years.

The only other control device presently being installed is an alkaline scrubbing system.[18] These units, however, have not been installed on NSPS recovery furnaces, but on older furnaces downstream from precipitators. The installation of these units has been confined to upgrading existing systems. Since the system is also designed to control TRS emissions, it will be more fully discussed in Section 4.2.1.

Table 4-2. PARTICULATE EMISSIONS DATA FOR THE NO. 4 RECOVERY FURNACE AT THE TACOMA, WASHINGTON, MILL, 1973 THROUGH 1981[15,17]

Date	Test Result (gr/dscf)
Aug. 1973	0.0192
Sept. 1973	0.0011
Oct. 1973	0.0240
Nov. 1973	0.0410
Dec. 1973	0.0101
Jan. 1974	0.0150
Feb. 1974	0.0100
Mar. 1974	0.0130
Apr. 1974	0.0140
May 1974	0.0120
June 1974	0.0120
July 1974	0.0061
Aug. 1974	0.0133
Sept. 1974	0.0069
Oct. 1974	0.0171
Nov. 1974	0.0096
Dec. 1974	0.0143
Jan. 1975	0.0218
Feb. 1975	0.0309
Mar. 1975	0.0499
Apr. 1975	0.0213
May 1975	0.0411
June 1975	0.0349
ON STRIKE	
Oct. 1975	No Test
Nov. 1975	No Test
Dec. 1975	0.0269
Jan. 1976	0.0445
Feb. 1976	0.0167
Mar. 1976	0.0112
Apr. 1976	0.0365
May 1976	0.0114
June 1976	0.0069
July 1976	0.0288
Aug. 1976	0.0139
Sept. 1976	0.0061
Oct. 1976	CURTAILMENT OF MILL
Nov. 1976	0.0217
Dec. 1976	0.0106
Jan. 1977	0.0697
Feb. 1977	0.0117
Mar. 1977	0.0182
Apr. 1977	0.0171
May 1977	0.0112
June 1977	0.0301
July 1977	0.0104
Aug. 1977	0.0257
Sept. 1977	0.0381
Oct. 1977	0.0254
Nov. 1977	0.0216
Dec. 1977	0.0235
Jan. 1978	0.0282
Feb. 1978	0.0358
WENT TO TESTING ONCE PER QUARTER	
* GR/SCF CONVERTED TO 7% O_2	
June 1978	0.0341
Sept. 1978	0.0186
Dec. 1978	0.0315
Mar. 1979	0.0413
June 1979	0.0333
Sept. 1979	0.0675
Dec. 1979	0.0356
Mar. 1980	0.0345
June 1980	0.0274
Sept. 1980	0.0476
Dec. 1980	0.0804
Mar. 1981	0.0306
June 1981	0.0321
Sept. 1981	0.0836
Dec. 1981	0.0298
Mar. 1982	0.026
June 1982	0.0523
Sept. 1982	0.0342

4.1.2 Smelt Dissolving Tanks

The exhaust gases from smelt dissolving tanks subject to the NSPS are vented through wetted fan type scrubbers or low pressure drop venturi scrubbers (4-10 inches of water) for particulate removal. Weak wash is used as both the dissolving medium and scrubbing medium at those facilities for which information is available. These control systems are comparable to those tested by the EPA during the NSPS development.

4.1.3 Lime Kiln

All lime kilns subject to the NSPS, except one, are controlled with venturi scrubbers, with pressure drops ranging from 4,230 to 8,460 pascals (17 to 34 inches of water). The lower pressure drops are associated with venturi scrubbers controlling emissions from fluidized bed calciners. Pressure drops of venturi scrubbers installed on rotary lime kilns range from 6,220-8,460 pascals (25-34 inches of water).

One mill has installed an electrostatic precipitator to control emissions from the rotary lime kiln subject to the NSPS. This ESP has a design SCA of 462 and a design outlet loading of 0.05 g/dscm (0.02 grains/dscf). The ESP was installed to achieve additional reduction over the NSPS because of the location of the mill.

The use of ESP's on lime kilns was investigated during the original NSPS development, and ESP's were considered capable of achieving lower particulate emissions than venturi scrubbers with pressure drops of about 7,470 pascals (30 inches of water). However, it was not considered feasible to base the NSPS on ESP's, since the industry commented that any noncondensable gases not combusted in the kiln might cause explosions in the ESP. Furthermore, a venturi scrubber was considered capable of controlling both particulate and TRS emissions.

Research has been done on the use of a fabric filter (baghouse) as an alternative control technique for kraft lime kilns.[19] A six-month pilot operation, conducted at a pulp mill in Canada, indicated that fabric filters are able to remove particulate at an efficiency of 99.9 percent. The conclusions of this research were that fabric filters can be used, the energy requirements are less than scrubbers, and the economics can be superior to a wet scrubber. However, full-scale systems using baghouses have not been installed so long-term performance data (emissions, maintenance, etc.) are not available.

4.2 TRS CONTROL

4.2.1 Recovery Furnace System

TRS emissions from a recovery furnace system can originate in the recovery furnace itself, or in the direct contact evaporator, if this type of evaporator is used. Most recent recovery furnace systems which have been installed are the non-contact design. In these furnaces, the furnace flue gases never directly contact the black liquor and TRS cannot be formed in the evaporator. The TRS emissions from the recovery furnace itself are controlled by maintaining proper process conditions.

TRS emissions that normally result from a direct-contact evaporator are controlled by either black liquor oxidation or conversion to a non-contact system. Black liquor oxidation inhibits the reactions between the combustion gases and black liquor that normally generate hydrogen sulfide. This is accomplished by oxidizing the Na_2S to $Na_2S_2O_3$ in the black liquor before it enters the direct contact evaporator. Air is the normal oxidizing agent, but molecular oxygen is used at one mill. In the non-contact system, direct contact between furnace gases and black liquor is eliminated, and hydrogen sulfide is prevented from forming.

The direct-contact and non-contact furnaces subject to the NSPS are using the same control technology as those tested by the EPA for development of the NSPS.

One recovery furnace subject to the NSPS is a cross recovery furnace. It was determined during the NSPS development that cross recovery furnaces cannot be operated to achieve the same TRS levels as straight kraft furnaces because of the higher sulfur content and lower heat content of the cross recovery liquor and the restriction on excess oxygen to oxidize the relative large quantities of sulfur compounds given off. A restriction of oxygen is necessary to prevent development of a sticky dust which can plug up the ESP and render furnace operation impossible.[20]

An add-on control technique for controlling TRS emissions from recovery furnaces is an alkaline adsorption system with carbon activated oxidation of the scrubbing solution.[18] This control technique has not been installed on recovery furnaces subject to the NSPS, but has been installed on older existing furnaces. Reductions in particulate and SO_2 emissions are also reported. This technique has been applied to control TRS emissions on

existing furnaces or cross recovery furnaces which do not have the combustion control capability for low TRS emissions. This technique is being promoted as an alternative to BLO, replacing an existing furnace, modifying an existing furnace to non-contact, or reducing the load on furnaces that are not capable of achieving the necessary TRS regulations.

4.2.2 Digester and Multiple-Effect Evaporator Systems

Control of TRS emissions from the digester and multiple-effect evaporators are considered together, since their emissions are normally combined for treatment. The noncondensable gases are incinerated in either a lime kiln, power boiler, or separate incinerator. Combustion of noncondensable gases in a lime kiln or separate incinerator provides nearly complete destruction of TRS compounds. Incineration of the gases was the basis for the NSPS.

The lime kiln has been the usual source for incinerating these gases. However, at least two of the NSPS lime kilns are equipped with tube coolers for heat recovery, and the mills are reluctant to pass the noncondensable gases through these coolers because of the possibility of an explosion resulting in damage to the coolers. The portion of the combustion air going directly to the kiln is not sufficient to accommodate the noncondensable gas stream from an equivalent size pulp mill. Therefore, these mills are incinerating the gases in either a power boiler or separate incinerator.

4.2.3 Brown Stock Washing System

Incineration of the vent gases is the only control technique employed on the brown stock washing systems subject to the NSPS. Incineration is the basis for the NSPS. Diffusion washers are generally being installed. Diffusion washing usually takes place in a closed reactor, and ideally there is no air involved. Therefore, the vent gases released are very small, when compared with the vacuum drum washers.[21] In fact, two diffusion brown stock washing systems subject to the NSPS were not required by the permitting agencies to be controlled by incineration because the washers are totally enclosed and are only open to the atmosphere to prevent over pressure or vacuum conditions during filling and emptying procedures.[22] Since this is a continuous process, the filling and emptying occurs on an infrequent basis. The vent gases from other diffusion washers subject to the NSPS are being incinerated in either a lime kiln, recovery furnace or separate incinerator.

Two vacuum drum washing systems are subject to the NSPS. The vent gases from one system are used as combustion air in a power boiler. The other vacuum drum washer is not controlled by incineration, but was granted an exemption from the standard because the mill did not have available an incineration device which could safely handle the gases economically. This vacuum drum washer was installed as a new fourth stage washer on an existing washing system.

4.2.4 Black Liquor Oxidation Systems

There are only two black liquor oxidation (BLO) systems subject to the NSPS. One BLO system uses molecular oxygen to oxidize the black liquor. There are no vent gases from this closed system and, therefore, no TRS emissions. The vent gases from the other BLO system go through a condenser and preheater, and are used as combustion air in a power boiler. The combustion of these gases reportedly does not result in any significant increase in fuel requirements or boiler operating problems.[1] Incineration of the vent gases and the use of molecular oxygen were the control techniques investigated during the NSPS development.

4.2.5 Smelt Dissolving Tank

There are no special TRS control devices for smelt dissolving tanks. TRS emissions are governed by process conditions; that is, the presence of reduced sulfur compounds either in the smelt or the water. The principal control option available is the choice of water in the smelt dissolving tank or the particulate control device. This control technique was the basis for the NSPS. All 11 of the smelt tanks subject to the NSPS, for which information is available, use weak wash as the dissolving and scrubbing medium.

4.2.6 Lime Kiln

The NSPS for TRS emissions from lime kilns is being achieved by utilizing process controls and good lime mud washing. At one lime kiln installation caustic is being added to the scrubber water. The use of caustic scrubbing in combination with process control and good mud washing was the basis for the NSPS. Several mills have designed the particulate scrubber with the capability to add caustic, if necessary. These mills have achieved compliance, based on a source test, without caustic addition,

but feel that once the continuous monitoring requirements are promulgated, caustic addition might be necessary to continuously achieve the NSPS during normal variations in the lime kiln process.

4.2.7 Condensate Stripping System

Only three condensate stripping systems are known to be subject to the NSPS. In both cases, the vent gases are incinerated. One of these incinerates the gases in a separate incinerator, while the other two incinerate the gases in a lime kiln. Incineration is the control technology upon which the NSPS was based.

4.3 REFERENCES

1. Trip Report - Champion International Corporation, Courtland, Alabama, May 20, 1982.

2. Letter from C. F. Johnson, Continental Forest Industries to Don R. Goodwin, U.S. EPA, dated May 21, 1982.

3. Trip Report - Union Camp Corporation, Montgomery, Alabama, May 19, 1982.

4. Letter from David S. Dillard, Jr., Nekoosa Paper Inc., to Don R. Goodwin, U.S. EPA, dated June 1, 1982.

5. Letter from Grey Forte, Tennessee Department of Public Health, to James Eddinger, U.S. EPA, dated March 16, 1982.

6. Letter from Stuart R. Cooper, Boise Cascade to James Eddinger, U.S. EPA, dated August 12, 1982.

7. Letter from A. M. Lindsey, International Paper Company, to Jim Eddinger, U.S. EPA, dated October 4, 1982.

8. Trip Report - Buckeye Cellulose Corporation, Oglethorpe, Georgia, September 16, 1982.

9. Telephone conversation between Ike Core of Continental Forest Industries, Hopewell, Virginia, to James Eddinger, U.S. EPA, on August 11, 1982.

10. Letter from Phillip H. Speir, Hammermill Paper Company, to James Eddinger, U.S. EPA, dated July 22, 1982.

11. Letter from Eric J. Schmidt, Container Corporation of America, to Don Goodwin, U.S. EPA, dated July 7, 1982.

12. Final Survey Results for Direct Contact Evaporator Recovery Boiler Electrostatic Precipitators, J. S. Henderson, J. E. Sirrine Company, TAPPI, March 1982, Vol. 65, No. 3.

13. Final Survey Results for Noncontact Recovery Boiler Electrostatic Precipitators; Part 1, Precipitator Design Features, J. S. Henderson, J. E. Sirrine Company, TAPPI, December 1980, Vol. 63, No. 12.

14. Final Survey Results for Noncontact Recovery Boiler Electrostatic Precipitators; Part 2, Precipitator Performance Results, J. S. Henderson, J. E. Sirrine Company, TAPPI, January 1981, Vol. 64, No. 1.

15. Trip Report - St. Regis Paper Company, Tacoma, Washington, May 25, 1982.

16. Source Testing Report - St. Regis Paper Company, Tacoma, Washington, EPA Report No. 74-KPM-15.

17. Information received from C. F. Kleeberg, EPA Region X, Olympia, Washington, April 29, 1983.

18. Letter and Enclosure from Ronald A. Jolicoeur, Teller Environmental Systems, to Don R. Goodwin, U.S. EPA, dated September 13, 1982.

19. Fabric Filters for Kraft Mill Lime Kilns, D. R. Lewis, Centurion Engineering Ltd., Pulp & Paper Canada, Vol. 80, No. 12, December 1979.

20. A Report on the Study of TRS Emissions from a NSSC-Kraft Recovery Boiler, Container Corporation of America, March 9, 1977.

21. Environmental Pollution Control-Pulp and Paper Industry, Part I Air, U.S. Environmental Protection Agency, EPA-625/7-76-001, October 1976.

22. Letter from Alan M. Lindsey, International Paper Company, to James Eddinger, U.S. EPA, dated December 17, 1982.

5. COMPLIANCE TEST RESULTS

EPA regional offices, State agencies, and kraft pulp mills were contacted to obtain compliance test information for new, modified, or reconstructed facilities. Test data for recovery furnaces, lime kilns, and smelt dissolving tanks were specifically requested.

The results of the survey show that there are 14 new recovery furnaces, 20 new lime kilns, and 16 new smelt dissolving tanks in operation which are subject to the NSPS. In addition, two existing recovery furnaces are subject to the NSPS since both were modified from a direct contact type to an indirect contact type furnace after the NSPS became effective. One of the new recovery furnaces is a cross recovery furnace, and two of the new lime kilns are fluidized bed calciners. Several new digesters, multiple-effect evaporators, brown stock washers, condensate strippers, and black liquor oxidation systems have been constructed since the NSPS became effective, but since the control technique employed is incineration in another process source, there is no compliance testing required and, therefore, no data are available. Compliance testing for these sources is not required if the gases are combusted in a lime kiln or recovery furnace subject to the NSPS or combusted in another device with a minimum combustion temperature of 1,200°F and a residence time of at least 0.5 second.

5.1 ANALYSIS OF NSPS COMPLIANCE TEST RESULTS

5.1.1 Recovery Furnace System

The results of compliance tests obtained from new and modified recovery furnaces are summarized in Table 5-1. Compliance test results for particulate emissions obtained on 13 recovery furnaces indicate compliance with the NSPS, with emissions ranging from 0.007 to 0.080 grams per dry standard cubic meter (g/dscm) [0.003 to 0.035 grains per dry standard cubic foot (gr/dscf)]. Compliance test results for TRS emissions obtained on 11 recovery furnaces range from 0.1 to 30 parts per million (ppm). The data indicate that all but two are in compliance with the NSPS. Two additional installations which are in the startup phase have not yet complied with the TRS standard. No Method 9 opacity data were supplied with the compliance test reports.

Table 5-1.
Compliance Test Results of
Recovery Furnaces Subject to NSPS [1-14]

Mill	Type[1]	Particulates		TRS	
		Control	Level gr/dscf	Control	Level (ppm)
A	NC	ESP (SCA=478)	0.013	Process	4.3
B	DC	ESP (SCA=453)	0.006	BLO	0.1
C	NC	ESP (SCA=587)	0.007	Process	4.4
D	DC	ESP (NA)	0.006	BLO	2.8
E	NC[2]	ESP	0.003	--	--
F	NC	ESP (NA)	0.035	Process	2.2
G	NC	ESP (SCA=461)	0.006	Process	
H	NC	ESP (SCA=438)	0.027	Process	2.3
I	NC	ESP (SCA=510)	0.012	Process	1.8
P[3]	NC	ESP (SCA=542)	0.013	Process	4.0
Q	NC	ESP (SCA=506)	0.033	Process	3.8
T	NC	ESP	0.018	Process	10
U	NC[2]	ESP (NA)	0.011	--	--
V	NC	ESP		Process	30
			NSPS = 0.044		NSPS = 5 ppm

1 NC = Non-Contact, indirect-contact type
DC = Direct-contact type

2 Furnace was modified from direct-contact to non-contact

3 Cross recovery furnace

The design surface area-to-volume (SCA) ratios for the ESP's installed to control emissions from the new recovery furnace systems ranged from 438 to 587 square feet of collecting plate area/1,000 actual cubic feet per minute of exhaust gas and averaged 497. The design SCA's of the ESP's tested by the EPA during the NSPS development ranged from 346 to 441 and averaged 393.

One mill reportedly had problems in initially complying with the TRS standard.[15] At this mill, it was found that the original design of the wet bottom ESP using unoxidized black liquor resulted in an increase in TRS concentrations as the furnace gas passed through the ESP. The TRS increase was traced to the air flow in the ESP which promoted contact between the flue gas and the unoxidized black liquor. Modifications were made to the duct work and internal baffling to reduce this contact by redirecting the gas flow. This recovery furnace is now in compliance. The two recovery furnaces not in compliance plus two additional new installations with wet-bottom ESP's have also reported problems in achieving the NSPS due to an increase in TRS emissions through the ESP.[16,17] Modifications similar to those discussed above have been made to these ESP's, and although the TRS emissions have been reduced, they have not met the NSPS. Additional modifications to achieve compliance are being investigated by the companies and vendors.

Since the EPA has not promulgated specifications for continuous monitoring systems, long-term TRS data showing whether these facilities are continuously achieving the NSPS are not available.

5.1.2 Smelt Dissolving Tanks

The results of compliance tests obtained on 12 new smelt dissolving tanks are summarized in Table 5-2. Either a venturi or wetted fan type scrubber is employed for particulate control, with weak wash as the scrubbing and dissolving medium in all cases. The particulate emissions ranged from 0.025 to 0.095 gram/kilogram of black liquor solids (g/kg BLS) [0.05 to 0.19 pound/ton of black liquor solids (T BLS)] and the TRS emissions ranged from 0.001 to 0.016 g/kg BLS (0.002 to 0.032 pound/T BLS). The compliance test data indicate that all the smelt dissolving tanks are in compliance with the NSPS except for one mill which has not been able to comply with the TRS standard.

Table 5-2.
Compliance Test Results of
Smelt Dissolving Tanks Subject to NSPS [1-12,26]

Mill	Particulates		TRS	
	Control	Level (#/TBLS)	Water Used	Level (#/TBLS)
A	Wetted Fan	0.18	Weak Wash	0.014
B	Wetted Fan	0.09	Weak Wash	0.004
C	Scrubber	0.05	Weak Wash	0.002
D	Venturi	0.19	Weak Wash	0.007
E		0.1		
F	Venturi	0.16	Weak Wash	0.004
G	Wetted Fan	0.06	Weak Wash	
H	Venturi	0.133	Weak Wash	0.032
I	Venturi	0.115	Weak Wash	0.008
P	Venturi	0.137	Weak Wash	
Q	Wetted Fan	0.1	Weak Wash	0.013
T	Venturi	0.13	Weak Wash	0.013
	NSPS = 0.2			0.0168

The smelt dissolving tank which is not in compliance with the TRS standard is utilizing the same control technology as the other installations. This mill has attempted to reduce the TRS emissions using various scrubbing liquids, but has not found a solution to continuously achieve the NSPS.[18] A continuous monitor was installed to help analyze the problem. Results of the monitoring indicate that the TRS standard can be achieved, but not on a continuous basis.[19] The monitoring data ranged from 2.8 to 14.7 ppm (0.0047 to 0.0247 #/T BLS) and averaged 5.5 ppm (0.0092 #/T BLS), on a 12-hour average basis. Of the 27 12-hour averages reported, 92.6 percent were below the NSPS level.

Another mill also reportedly had problems in complying with the NSPS. At this mill, the stack height resulted in too much draft, causing a portion of the exhaust to bypass the scrubber. A damper was installed to bleed in cool air to reduce the exhaust temperature and the draft. This corrected the problem, and the smelt dissolving tank is now in compliance.[4]

5.1.3 Lime Kiln

The results of compliance tests obtained on lime kilns subject to the NSPS are summarized in Table 5-3. The particulate emissions ranged from 0.027 to 0.14 g/dscm (0.012 to 0.063 gr/dscf) for gas-fired kilns, and 0.079 to 0.169 g/dscm (0.034 to 0.074 gr/dscf) for oil-fired kilns. The TRS emissions ranged up to 7.3 ppm. The test data indicate that all the lime kilns are in compliance with the NSPS.

All but one of the lime kilns are controlled by a venturi scrubber, with design pressure drops of 4,233 to 8,217 pascals (17 to 33 inches of water). The pressure drops of the scrubbers tested by the EPA during the NSPS development ranged from 4,233 to 7,968 pascals (17 to 32 inches of water).

Two of the lime kilns subject to the NSPS are fluidized bed calciners. The NSPS covers all types of lime kilns (i.e., rotary kilns, fluidized bed calciners). However, during the NSPS development only rotary kilns were tested by the EPA because fluidized bed calciners were in limited used in the kraft pulping industry. Fluidized bed calciners were in operation at only four mills and their production rates were under 150 tons per day of quicklime. The two fluidized bed calciners subject to the NSPS have production rates of about 236 megagrams (260 tons) per day. As shown in Table 5-3, both fluidized bed calciners are in compliance with the NSPS.

Table 5-3.
Compliance Test Results of
Lime Kilns Subject to NSPS 1-4,6,8,11,20-26

Mill	Type[1]	Particulates Control	Particulates Level gr/dscf	TRS Control	TRS Level (ppm)
Gas-Fired Kilns					
A	Rotary	Venturi (ΔP-32")	0.055	Process	4.5
B	Rotary	Venturi (ΔP-33")	0.046	Process	0.5
C	Rotary	Venturi (ΔP-28")	0.039	Process	5.0
J	Fluidized Bed	Venturi	0.050	Process	2.0
M	Rotary	Venturi	0.012		7.3
N		Venturi	0.063		1.75
O		Venturi	0.061		4.5
Q	Rotary	Venturi (ΔP-28")	0.043	Process	5.3
R	Rotary		0.037		5.9
T	Rotary	Venturi	0.013	Process	2.7
Oil-Fired Kilns					
D	Rotary	Venturi (ΔP-28")	0.031	Process	6.8
E		Venturi	0.034	Caustic	3.8
I	Fluidized Bed	Venturi (ΔP-20")	0.074	Process	6.7
K	Rotary	ESP (SCA-461)	0.035		
L	Rotary	Venturi (ΔP-30")	0.081		4.6
		NSPS =	0.067 (Gas)		8.0
			0.13 (Oil)		

An ESP is used to control particulate emissions from one lime kiln. This lime kiln has not been compliance tested for TRS emissions. Monitoring results indicate that the TRS standard can be achieved, but presently not on a continuous basis. The kiln operates with a low cold-end temperature for energy conservation; and caustic scrubbing is not an option, because the ESP is used for particulate control. The company is trying to achieve the NSPS by good lime mud washing. If the NSPS is not achieved with mud washing, the company is considering using lime mud oxidation to achieve the NSPS.[25]

Only one kiln installation is using caustic addition for TRS control. Several are designed to add caustic, if necessary. Process controls and good mud washing are the techniques used at the other lime kiln installations for TRS control.

The EPA has not promulgated specifications for continuous monitoring systems, so long-term TRS data showing the performance of these TRS control systems (both caustic and noncaustic systems) are not available.

5.2 REFERENCES

1. Memo from Janis Forehand, EPA Region VI, to Jim Eddinger, EPA, dated June 29, 1982.

2. Letter from C. F. Johnson, Continental Forest Industries, to Don R. Goodwin, U.S. EPA, dated May 21, 1982.

3. Letter and enclosures from Philip H. Speir, Hammermill Paper Company, to Jim Eddinger, U.S. EPA, dated August 19, 1982.

4. Trip Report - Union Camp Corporation, Montgomery, Alabama, May 19, 1982.

5. Letter from Grey Forte, Tennessee Department of Public Health, to James Eddinger, U.S. EPA, dated March 16, 1982.

6. Trip Report - Champion International Corporation, Courtland, Alabama, May 20, 1982.

7. Memo from Frank W. Lilley, EPA Region I, to Stanley T. Cuffe, U.S. EPA, dated March 19, 1982.

8. Letter from Les Oakes, Georgia Department of Natural Resources, to James A. Eddinger, U.S. EPA, dated April 19, 1982.

9. Telephone Conversation between Gary Gross, EPA Region III, and James Eddinger, U.S. EPA, on June 22, 1982.

10. Letter from Eric J. Schmidt, Container Corporation of America, to Don Goodwin, U.S. EPA, dated July 7, 1982.

11. Trip Report - Washington State Department of Ecology, Olympia, Washington, May 24, 1982.

12. Memo and enclosure from Janis Forehand, EPA Region VI, to Jim Eddinger, U.S. EPA, dated December 22, 1982.

13. Letter and enclosures from A. M. Lindsey, International Paper Company, to James Eddinger, U.S. EPA, dated December 20, 1982.

14. Letter and enclosure from John E. Pinkerton, NCASI, to James A. Eddinger, U.S. EPA, dated April 8, 1983.

15. Telephone Conversation between Phillip Speir, Hammermill Paper Company, and James Eddinger, U.S. EPA, on August 10, 1982.

16. Telephone Conversation between Keith Bentley, Georgia-Pacific Corporation and James Eddinger, U.S. EPA, on September 28, 1982.

17. Meeting Report - Industry Representatives and EPA Personnel, Durham, North Carolina, April 14, 1983.

18. Letter and enclosures from David E. Peakes, Boise Cascade Corporation, to James Eddinger, U.S. EPA, dated December 9, 1982.

19. Letter from David E. Peakes, Boise Cascade Corporation, to James Eddinger, U.S. EPA, dated November 8, 1982.

20. Total Reduced Sulfur Emission Compliance Test Performed at Willamette Industries, Inc., Hawsville, Kentucky, Harmon Engineering and Testing, Auburn, Alabama. September 1981.

21. Compliance Testing of Particulate Emission from the No. 2 Lime Kiln at the Willamette Industries, Inc. Bleached Pulp Plant, Hawsville, Kentucky, Kenvirons, Inc., Frankfort, Kentucky, September 1981.

22. Letter from J. H. Millican, The Buckeye Cellulose Corporation, to Don Goodwin, U.S. EPA, dated June 7, 1982.

23. Letter from Ken Berryman, County of Shasta Department of Health Services, to James A. Eddinger, U.S. EPA, dated June 11, 1982.

24. Memo from Jim Herlihy, EPA Region X, to Jim Eddinger, U.S.EPA, dated March 24, 1982.

25. Trip Report - Longview Fibre Company, Longview, Washington, May 26, 1982.

26. H. A. Lewis, Jr., Arkansas Department of Pollution Control and Ecology, to J. Eddinger, EPA:ISB, June 1, 1983, Compliance Test Reports.

6.0 COST ANALYSIS

The purpose of this chapter is to present updated capital and annualized costs for the control systems used to achieve the NSPS. The costs are presented for each of the affected facilities in a 907 megagrams (1,000 tons) per day kraft pulp mill. The cost-effectiveness of the control systems is also presented. All costs are in terms of February 1982 dollars. The costs presented for achieving the particulate standards are the incremental control costs over the economic recovery level. Actual industry costs are presented as a comparison, where available.

The capital cost of a control system includes all the cost items necessary to design, purchase, and install the particular device or system. The capital cost includes the purchased costs of the major control device and auxiliaries such as pumps, fans, and instrumentation; the equipment installation cost including foundations, piping, electrical wiring, and erection; and the cost of engineering, construction overhead, and contingencies.

The annualized cost of a control system is a measure of what it costs the company to own and operate the system. The annualized costs include direct operating costs such as labor, utilities, and maintenance; and capital related charges such as depreciation, interest, administrative overhead, property taxes, and insurance.

6.1 UPDATE COST FOR THE AFFECTED FACILITIES

The NSPS for kraft pulp mills cover particulate and TRS emissions. The updated costs, including capital costs, annualized costs, and credits for recovered particulate, and the cost effectiveness of achieving the NSPS for each system are shown in Table 6-1. These costs were updated to February 1982 using the Chemical Engineering plant cost index. The original costs were presented in the NSPS support document and were calculated based on the fourth quarter of 1975.[1] The costs presented for controlling particulate and TRS emissions from the recovery furnace are revised costs,[2] based upon information supplied by the companies on

Table 6-1. Capital Costs, Annualized Costs, and Cost Effectiveness Of Achieving the NSPS for 907 Megagrams Per Day Kraft Pulp Mill

Source	Control Device	Capital Costs	Annual Cost	Credits	Emission Reductions (T/Y)	Cost Effectiveness ($/T)
Particulate sources						
Recovery Furnace (DC)	ESP	1,512,000	271,800	(132,160)	1,180	118
Recovery Furnace (NC)	ESP	1,322,600	240,600	(93,070)	831	178
Smelt Tank	Scrubber	181,400	59,260	(23,860)	213	166
Lime Kiln	Venturi Scrubber	41,500	37,140	(8,460)	180	159
TRS Sources						
Dig. & Evap.	Inc.	292,000	67,000	---	410	163
Washers - Vacuum Drum	Inc.	584,000	116,000	---	49	2,370
- Diffusion	Inc.	124,000	44,000	---	49	898
Recovery Furnace (DC)	Process & BLO	955,000	777,100	---	2,439	319
Recovery Furnace (NC)	Process	1,551,000	494,000	---	2,439	203
B.L. Oxid. System	Inc.	506,000	148,000	---	16	9,250
Lime Kiln	Process, Mud Washing & Caustic	0	110,000	---	124	887
Cond. Stripper	Inc.	35,000	12,000	---	329	37
Smelt Tank	Water	0	0	---	29	0

actual recovery furnace system operations. Table 6-1 also presents the emission reduction resulting from application of control techniques. The particulate emission reductions are calculated based upon the difference between the economic recovery levels and the NSPS levels. The TRS emission reductions are calculated based upon the difference between the uncontrolled levels reported in the NSPS support document and the NSPS levels.

6.1.1 Particulate Control

For each of the particulate control devices in Table 6-1, the costs presented are the incremental control costs over the economic recovery levels. Since the particulate is a valuable material, it is economical to recover and recycle it to the process. The credits for recovered particulate are calculated assuming that all the particulate from the recovery furnace and smelt dissolving tank is sodium sulfate valued at $112 per ton, and that the recovered particulate from the lime kiln is valued at $47 per ton.[3-7] In calculating the incremental control costs, the control systems selected for economic recovery were a 95 percent efficient ESP for the direct contact recovery furnace, a 97 percent efficient ESP for the non-contact recovery furnace, a demister system (80 percent efficient) for the smelt dissolving tank, and a venturi scrubber with a 3,740 pascals (15-inch) pressure drop for the lime kiln.[8] The cost-effectiveness values were calculated based on the incremental annual cost, including credits, and the incremental emission reduction achieved by the NSPS.

Actual capital costs were obtained from several companies for the control devices associated with facilities subject to the NSPS. The capital costs obtained were assumed to be from the year the unit started operation unless actually stated by the company. The updated industry-reported data ranged from $3 million to $6.4 million for ESP's controlling non-contact furnaces.[3,4,6,9] One mill reported a cost of $2.5 million for an ESP controlling a direct-contact furnace.[7] For comparison, the capital costs estimated for achieving the NSPS are $5.1 million for a direct-contact furnace and $5.9 million for a non-contact furnace.[2]

Updated industry capital costs for scrubbers installed on four smelt dissolving tanks ranged from $49,000 to $226,000. For comparison, the capital cost estimated for a scrubber to achieve the NSPS is $229,000.[2]

Industry data were available for six lime kiln installations, with the updated capital costs ranging from $75,000 to $660,000 dollars.[3,4,6,7,10,11] The average of the six updated industry costs is $270,000. For comparison, the capital cost estimated for a 7,470 pascals (30 inches of water) pressure drop scrubber is $275,000.[2]

6.1.2 TRS Control

For all TRS sources, no credits are estimated, because the TRS compounds are not actually recovered in a control device. The cost-effectiveness of the various TRS controls ranges from zero dollars for the smelt dissolving tank to $9,250 for the black liquor oxidation system. The vacuum drum type brown stock washing system is the only other affected facility with a cost-effectiveness above $1,000 per ton.

Except for the recovery furnaces, lime kilns, and smelt dissolving tanks, the TRS emissions from the affected facilities are controlled by incineration in either a lime kiln, power boiler, or separate incinerator. The cost of the incineration system consists of the necessary piping and blowers to collect the gas streams, and delivery piping and controls to inject the gases into the incineration point. The costs shown in Table 6-1 for brown stock washers are for a vacuum drum system and include hooding costs. The costs shown in Table 6-1 for the black liquor oxidation system include condensers.

The cost estimate shown in Table 6-1 for the direct contact furnace is based on the cost of black liquor oxidation. The cost shown in Table 6-1 for the non-contact furnace is based on the incremental cost between the non-contact furnace with a concentrator, and a direct contact furnace which has a direct contact evaporator. Also included is a charge for the heat loss of the non-contact furnace compared to the direct contact furnace. The heat loss was calculated assuming that the flue gas is 40°F hotter than the direct contact furnace flue gas. Included in the annual cost for the

direct contact furnace is a charge for the heat loss resulting from the oxidation of the black liquor. The heat loss was calculated assuming that the heat content of the black liquor is reduced by 4 percent during black liquor oxidation.

The control technique for reducing TRS emissions from the smelt dissolving tank is to use water which is essentially free of dissolved TRS compounds in both the smelt dissolving tank and the associated scrubber. No control costs are presented in Table 6-1, because this feature can be designed into a new mill at essentially no cost.

The costs for the lime kiln are based on caustic addition to the particulate scrubber and the cost of the energy needed to raise the cold-end temperature of the kiln 55.5°C (100°F).

Presently, only two mills have BLO systems subject to the NSPS. One mill uses oxygen as the oxidizing medium and has no vent gases. This mill reported an operating cost of $508,000 per year for the oxygen. The other mill incinerates the offgases in a power boiler. This BLO system is the only BLO system controlled by incineration in the industry. The annualized costs of $148,000 for BLO systems shown in Table 6-1 is based on incineration of the vent gases. The principal reason for the high cost-effectiveness shown in Table 6-1 is the small amount (16 tons per year) of TRS controlled. Of the eight TRS sources, the BLO system emits the least amount of uncontrolled TRS from a typical pulp mill.

The high cost-effectiveness shown in Table 6-1 for the vacuum drum type washer system is also the result of a low level of uncontrolled TRS emissions. However, many mills are installing diffusion washers instead of vacuum drum washers. The newer diffusion washers are a closed reactor, and the vented gas volume is much less than that from a vacuum drum system. The vent gases from the diffusion washer are usually incinerated with the vent gases from the associated continuous digesters. The cost of controlling a diffusion washing system would therefore be much less than the cost for controlling a vacuum drum washing system because smaller ducts and no hooding would be required. The updated capital cost reported by one mill for controlling the vent gases from a diffusion washer with a capacity of

743 megagrams (816 tons) per day is $101,000.[6] This is about one-fifth the capital cost estimated in Table 6-1 for controlling a vacuum drum washer system. The annualized costs for a diffusion washing system are estimated at about $44,000 which, assuming the TRS emission reduction for a vacuum drum system, result in a cost-effectiveness of about $900 per ton of TRS controlled.[2]

Actual industry data for controlling TRS emissions from digesters, evaporators, BLO systems, and condensate stripping systems were not provided and therefore cannot be compared to Table 6-1.

6.2 REFERENCES

1. Standards Support and Environmental Impact Statement, Volume 1: Proposed Standards of Performance for Kraft Pulp Mills, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, Publication No. EPA-450/2-76-014a, September 1976.

2. Memo from James Eddinger, U.S. EPA, to Ken Durkee, U.S. EPA, dated November 8, 1982.

3. Trip Report - Union Camp Corporation, Montgomery, Alabama, May 19, 1982.

4. Letter from Philp H. Speir, Hammermill Papers Company, to James Eddinger, U.S. Environmental Protection Agency, dated July 22, 1982.

5. Trip Report - Longview Fibre Company, Longview, Washington, May 26, 1982.

6. Trip Report - Buckeye Cellulose Corporation, Oglethorpe, Georgia, September 16, 1982.

7. Letter from David S. Dillard, Jr., Nekoosa Papers Inc., to Don R. Goodwin, U.S. Environmental Protection Agency, dated June 1, 1982.

8. Memo from James Eddinger, U.S. EPA, to Ken Durkee, U.S. EPA, dated

9. Letter from Eric J. Schmidt, Container Corporation of America, to Don Goodwin, U.S. Environmental Protection Agency, dated July 7, 1982.

10. Letter from Ken Berryman, Shasta County Department of Health Services, to James A. Eddinger, U.S. EPA, dated June 11, 1982.

11. Memo from Jay M. Sinnott, EPA Region VIII, Montana Office, to Jim Eddinger, U.S. EPA, dated June 22, 1982.

7. ENFORCEMENT ASPECTS

EPA regional offices, State agencies, the NCASI, and companies subject to the NSPS were contacted to determine any problems with either enforcing the NSPS or complying with the NSPS.

Discussions with EPA offices and State agencies indicated that there are no problems in enforcing the NSPS. The Tennessee State Agency did express concerns about kraft mills not being required to continuously monitor TRS emissions because the EPA has not yet promulgated the TRS monitoring specifications.[1] These specifications were proposed on July 20, 1981, (46 FR 3787) and are scheduled for promulgation in 1983. Once promulgated, all recovery furnaces and lime kilns subject to the NSPS will be required to continuously monitor TRS emissions.

The Alabama State Agency stated that more investigation is needed concerning incineration of the exhaust gases from brown stock washers in kraft recovery furnaces.[2] The one mill which has received an exemption from EPA for their washer system is located in Alabama. This issue was investigated and the findings are discussed in Chapter 8.

The EPA Region I office suggested that the aging factor of ESP's be included in the review.[3] This comment was made because a mill in the region has overdesigned their ESP in anticipation of performance deterioration. The possible deterioration of ESP's performance was commented on by the industry during the NSPS development and was investigated at that time. As discussed in Chapter 4, this issue has been reinvestigated and a problem does not appear to exist in an ESP's capability in achieving the NSPS level over the long term.

The Washington State Agency was asked about the need to develop standards for water treatment ponds. The Agency commented that they have no problems with odors from treatment ponds, since they have received no complaints. However, agency personnel commented that the retention times of the ponds at mills in Washington are not as long as ponds at mills elsewhere in the country. Information from industry personnel indicate that most new pulping installations have, and would in the future, install condensate stripping systems to either reduce the BOD load to the treatment

facility, control odors from the mill's recycle water, or control odor from the ponds.[4,5,6]

The NCASI indicated three areas to consider in the review of the NSPS.[7] The first area pertained to a smelt dissolving tank which has not been able to meet the TRS standard when using the control technology upon which the standard is based. This was discussed in Chapter 5. The second area pertained to the ability of a lime kiln equipped with an ESP to achieve the TRS standard on a routine basis, since there is no opportunity to add caustic to the scrubbing water for additional TRS control. The NSPS for TRS from lime kilns is based on process controls, good lime mud washing, and caustic scrubbing. This is discussed in more detail in Chapter 8. The third area recommended for consideration is the use of a wet bottom ESP using unoxidized black liquor. ESP design could promote contact between the flue gas and the liquor in the bottom of the ESP resulting in an increase in TRS concentrations as the furnace flue gas passes through the ESP. These items were investigated and analyzed, and the findings are discussed in Chapter 8.

Mill personnel contacted during this review indicated that, except for the cases discussed above, they have no problems in complying with the NSPS. As previously discussed in Chapter 5, some companies had problems in initially achieving the NSPS during startup. These problems were design or installation problems and were successfully corrected with modifications. The companies also commented that they have not experienced any problems in interpreting the NSPS or in degradation of control equipment performance in terms of emissions or operability since initial installation. These units subject to the NSPS have generally been in operation less than 3 years.

7.1 REFERENCES

1. Letter from Greg Forte, Tennessee Department of Public Health, to James Eddinger, U.S. EPA, dated March 16, 1982.

2. Letter from Glen Golson, Alabama Air Pollution Control Commission, to James A. Eddinger, U.S. EPA, dated March 23, 1982.

3. Memo from Frank W. Lilley, EPA Region I, to Stanley T. Cuffe, U.S. EPA, dated March 19, 1982.

4. Trip Report - Champion International Corporation, Courtland, Alabama, May 20, 1982.

5. Trip Report - Longview Fibre Company, Longview, Washington, May 26, 1982.

6. Letter from John E. Pinkerton, NCASI, to James A. Eddinger, U.S. EPA, dated April 26, 1982.

7. Letter from John E. Pinkerton, NCASI, to James A. Eddinger, U.S. EPA, dated August 19, 1982.

8. ANALYSIS OF POSSIBLE REVISIONS TO THE STANDARDS

EPA regional offices, State agencies, and industry organizations were contacted to determine the number and location of new and modified facilities subject to the NSPS. Available NSPS compliance test data and opinions of control agency and industry personnel regarding all facets of the NSPS were solicited. As shown in Chapter 5, data on facilities subject to the NSPS indicate that, except for two recovery furnaces and one smelt dissolving tank, all facilities are in compliance with the NSPS. No new control technology has emerged since the development of the NSPS. Some start-up difficulties in complying with the NSPS for TRS emissions from recovery furnaces, lime kilns, and smelt dissolving tanks have been reported. No difficulties or problems have been reported in terms of enforcing the NSPS. The only criticism voiced of the NSPS was excessive paperwork due to recordkeeping requirements.

This chapter will analyze possible revisions to the standard for each affected facility.

8.1 POSSIBLE REVISIONS TO NSPS

8.1.1 Recovery Furnace Systems

All recovery furnace systems subject to the NSPS, and for which compliance test results are available, are in compliance with the particulate and TRS standards, except for two recovery furnaces which have not achieved the TRS standard. Although there has been improvement in the ESP's used, the particulate test results do not provide sufficient justification for revision of the particulate standard. There have been no improvements that would provide justification for revising the TRS standard. TRS emissions are controlled by maintaining proper process conditions and use of either a non-contact furnace, or a direct contact furnace with black liquor oxidation.

Method 9 opacity data were not supplied with the compliance test results for particulate matter. The particulate and Method 9 opacity data obtained during the NSPS development were reexamined, and provided no justification for revising the present opacity standard.

The NCASI indicated that a potential problem area might exist in complying with the NSPS for TRS emissions if a wet-bottom ESP with unoxidized black liquor is used. Compliance test results obtained on six wet-bottom ESP's installed on recovery furnaces subject to the NSPS using unoxidized black liquor indicated that all but two are in compliance with the TRS standard. One mill initially had a problem during startup with the original design of the wet-bottom ESP which resulted in an increase in TRS emissions. Modifications were made to the ductwork and internal baffling to decrease contact of the unoxidized liquor with the flue gas. This recovery furnace is now in compliance. The two recovery furnaces not in compliance plus two additional new installations with wet-bottom ESP's have not achieved the TRS standards due to an increase in TRS emissions through the ESP. These installations are in the startup phase. Similar modifications have been made to these ESP's, and although the TRS emissions have been reduced, they have not met the NSPS. Additional baffling as well as other alternatives to achieve compliance are being investigated by the companies and vendors.

Presently, the mills with wet-bottom ESP's using unoxidized black liquor are not required to continuously monitor the recovery furance system until the continuous monitoring system specifications are promulgated. Therefore, continuous monitoring data will not be available to show that the NSPS can be continuously met under normal operating conditions at these installations.

The types of ESP's tested by the EPA (in 1972) during the NSPS development were dry-bottom ESP's or wet-bottom ESP's installed on direct-contact recovery furnaces (using oxidized black liquor). Wet-bottom ESP's are extensively used on recovery furnaces equipped with direct-contact evaporators.[1] Oxidizing the black liquor prior to its introduction into the direct-contact evaporator and, therefore, prior to the wet-bottom ESP, prevents stripping of the TRS during contact with the flue gas. Direct-contact recovery furnaces subject to the NSPS and equipped with wet-bottom ESP's employed black liquor oxidation and are in compliance with the NSPS.[2,3]

The non-contact recovery furnace was first introduced in the late 1960's. The ESP's installed on the first several non-contact recovery furnaces had dry-bottom designs. However, many companies favored the wet-bottom design because of increased maintenance requirement and salt cake handling problems of the dry-bottom units. The first wet-bottom ESP using unoxidized black liquor was installed on a non-contact recovery furnace around 1971. An additional five wet-bottom ESP's using unoxidized black liquor began operation between 1974 and 1978. The question of stripping TRS from unoxidized black liquor at the ESP wet-bottom by the flue gas was not a priority concern by the industry until the NSPS was promulgated and the use of non-contact furnaces and wet-bottom ESP's increased.[1] In 1978, the NCASI reviewed the situation and tested a wet-bottom ESP. The study indicated that there was little, if any, TRS contribution from the flue gas contact with the unoxidized black liquor.[4] Therefore, companies elected to install wet-bottom ESP's because information available indicated that the TRS standards could be achieved if TRS levels from the recovery furnace were low.[5]

As stated previously, some companies are having problems in achieving the NSPS due to a pickup of TRS emissions in the wet-bottom ESP because of contact between the flue gas and the unoxidized black liquor. These companies have, however, indicated that the TRS standard is being achieved from the recovery furnace prior to the ESP.[6] The NCASI is currently gathering information on these wet-bottom ESP installations in an effort to identify the factors influencing the concentrations of TRS at the ESP outlet. Data on internal ESP design, air flow within the ESP, flue gas characteristics, and black liquor characteristics are being obtained from the mills. This study should be completed in early 1984 and will hopefully identify modifications that can be made to bring these units into compliance.

Based on the information available at this time, there is no justification for revising the NSPS for recovery furnace systems because: (1) some wet-bottom units are capable of achieving the NSPS, (2) the problem is now known and companies have indicated that dry-bottom units will be installed until the problem with wet-bottom units is solved[6],

(3) the companies and vendors are still investigating ways to achieve the NSPS for those out of compliance, and (4) the NCASI is conducting a study to determine the factors that influence TRS emissions from a wet-bottom ESP.

8.1.2 Smelt Dissolving Tanks

The NSPS is based on the use of a low energy scrubber and the use of water that is not highly contaminated with dissolved sulfides. The emission control techniques being used are the same as those upon which the NSPS is based. All smelt dissolving tanks subject to the NSPS and for which compliance test data are available are in compliance with the NSPS, except for one mill which has not been able to meet the TRS standard. The mill has attempted to reduce the TRS emissions using various scrubbing liquids, but has not found a solution to continuously achieve the TRS standard. A continuous monitor was installed to help analyze the problem. Results of the monitoring indicate that the TRS standard can be achieved, but not on a continuous basis. Data obtained during the NSPS development also indicated that there is a large range of variation in emissions from even well-controlled facilities. The level of the NSPS was set to allow for some degree of variation in the emissions. However, no continuous monitoring data were available at the time of the NSPS development to indicate the variation in emissions from an individual smelt tank. The data available were from short-term source tests which indicated only the variation in emissions between well-controlled smelt dissolving tanks. Therefore, there is sufficient justification to revise the TRS standard for smelt dissolving tanks based upon the analysis of the monitoring data. The impact of this revision will be minimal, since it will not result in a change in the basis for the standard (i.e., control technology used).

The promulgated standard requires that compliance be determined by summation of the mass emission rate of each TRS compound from the concentration results of Method 16. This provision [FR 60.285(d)(3)] was added during promulgation of the NSPS to enable a more accurate determination of the mass emission rate. Since promulgation, the EPA has proposed (46 FR 31904) Method 16A (Impinger Technique) as an equivalent method to Method 16 for

determining TRS concentrations. Method 16A is simple and much cheaper (60 to 80 percent lower costs) to operate, and involves fewer and less complicated components that reduce chances of measurement error. Method 16A results in a single value for all reduced sulfur compounds and does not measure each individual compound. Therefore, as presently written, the regulation would prevent the use of Method 16A (when promulgated) to determine compliance for smelt dissolving tanks.

The mass TRS values reported in the NSPS background information document and upon which the NSPS is based are in terms of equivalent H_2S. That is, the total TRS concentration measured by Method 16 was assumed to be H_2S when calculating the mass emission rate. When the provision for calculating the mass rate was modified at promulgation, no changes were deemed necessary to the numerical standards, because the difference in the calculated mass values were not significant. Therefore, since Method 16A is equivalent to and less expensive than the existing method, sufficient justification exists to revise the standard to allow the industry to use Method 16A in determining compliance for smelt dissolving tanks. The revision would not change the numerical standards for reasons previously discussed. The standard could be revised to be identical to the 111(d) guideline level which defines the mass level in terms of TRS as H_2S. The impact of this revision would be negligible, since it would not result in a change in the basis for the standards (i.e., control technology used), but only in how the mass value is calculated and reported.

8.1.3 Lime Kiln

Lime kilns subject to the NSPS and for which compliance test results are available are in compliance with both the particulate and TRS standards. One lime kiln which is in start-up has not been compliance tested, but has reported difficulties in achieving the TRS standard. This lime kiln is equipped with an ESP and does not have the opportunity to add caustic to the scrubbing water for additional TRS control. The TRS standard is based on caustic addition in conjunction with process controls and good lime mud washing. Most lime kilns subject to the NSPS have demonstrated compliance with the NSPS without caustic addition. These kilns are

controlled for TRS by maintaining proper process conditions and good mud washing. The results of these short-term compliance tests along with short-term data obtained during the NSPS development indicate that the level of the TRS standard can be met wtihout caustic addition. However, the NSPS was based on the long-term monitoring data from a lime kiln controlled by a caustic scrubbing system. Presently, the mills are not required to continuously monitor the lime kiln system until the continuous monitoring system specifications are promulgated. Until continuous monitoring data are available, insufficient data exist for making any definitive judgement about the ability to continuously achieve the TRS standard without caustic addition.

The one lime kiln equipped with the ESP which has not yet met the TRS limit is in the start-up phase. The mill is trying to improve the lime mud quality in order to achieve the NSPS. If improvements in the mud washing system are not sufficient to reduce TRS emissions to the NSPS level, lime mud oxidation will likely be employed. Lime mud oxidation is already employed at the mill for the other existing lime kilns. This lime kiln also operates at a lower cold-end temperature than other kilns subject to the NSPS. It would appear that raising the cold-end temperature from 300°F to 450°F (as costed out in the NSPS) is also an alternative if the mud washing proves insufficient.

Therefore, since the lime kiln equipped with the ESP is still in startup, and there exist other control alternatives which other kilns are already using, there is not sufficient justification at the present time for revision to the NSPS. Information pertaining to this area will be analyzed as it becomes available.

The particulate standard is based on venturi scrubbers because the TRS standard is based on caustic addition, and during the original NSPS development the industry contended that the use of an ESP could cause an explosion. The industry postulated that the noncondensable gases added to the kiln combustion air for incineration might explode in the ESP when flameout occurred in the kiln. Only one lime kiln installation was controlled by an ESP at the time of the NSPS development. Since the proposal of the NSPS, ESP's have been installed on lime kilns at two mills. Both ESP systems are equipped with automatic cutoff systems for preventing explosions.

The NSPS is, nevertheless, based on a venturi scrubber with caustic addition. A revision to the particulate standard based on the performance of an ESP cannot be considered, unless it is determined that the TRS standard can be continuously achieved without caustic scrubbing or a corresponding revision to the TRS standard is made reflecting the level achievable with process controls and good mud washing only. The latter option was considered during the NSPS development program. However, no new data or control systems have come available that would justify revising the NSPS.

As discussed in Chapter 4, research has been done on the use of a baghouse for kraft lime kilns. However, full-scale systems using baghouses have not been installed, so long-term performance data are not available, and therefore, the baghouse cannot be used as a basis for the NSPS or a revision.

8.1.4 Digester and Multiple-Effect Evaporator Systems

In all cases, the TRS emissions from digesters and multiple-effect evaporators subject to the NSPS are controlled by incineration of the noncondensable gases in either a lime kiln, power boiler, or separate incinerator. Incineration of the gases in the lime kiln is the basis for the NSPS. Therefore, there is no justiciation for revision to the present NSPS for digesters and multiple-effect evaporators.

8.1.5 Brown Stock Washer Systems

TRS emissions from washer systems subject to the NSPS are generally controlled by incineration of the vent gases. The NSPS states that a washer system (or a black liquor oxidation system) can be exempted from the standard if the owner or operator demonstrates that incineration of the exhaust gases in an existing facility is technologically or economically not feasible. One company has received an exemption from the standard for an additional washer stage.

As discussed in Chapter 6, the cost of control of TRS emissions from vacuum drum type washer systems is estimated to be about $2,400/ton of TRS removed. This value is considerably higher than that for the other TRS sources. Vacuum drum type washer systems were generally used at the time of the NSPS development. However, the majority of washer systems subject to the NSPS are the diffusion types which do not have the hooding requirements or the large gas volumes of the vacuum drum types. As shown in

Chapter 6, data supplied by one company indicate that the capital cost of controlling emissions from diffusion washers are about one-fifth the cost of controlling emissions from vacuum drum washers. Therefore, the cost-effectiveness when using a diffusion washer is estimated to be about $900/ton of TRS removed and will be similar to the other TRS sources.

In summary, there is a trend towards use of diffusion washers that are less costly to control. Therefore, there is no justification for revision to the standard for brown stock washer systems.

8.1.6 Black Liquor Oxidation Systems

Presently, only two black liquor oxidation (BLO) systems are subject to the NSPS. TRS emissions from one system are controlled by incineration of the vent gases in a power boiler, and the other system uses molecular oxygen as the oxidizing medium so there are no gases vented. These two control techniques were evaluated during the NSPS development.

As presented in Table 6-1, the cost effectiveness of incinerating the BLO gases is over $9,000 per ton of TRS removed. As discussed in Chapter 6, the high cost effectiveness is due to the small amount (16 tons per year from a 1,000 ton per day mill) of TRS controlled. Although the industry has demonstrated the control technology, the cost-effectiveness of control would provide justification for revision to the standard for BLO systems.

The impact of rescinding the standard for BLO systems would depend on the number of direct contact recovery furnaces installed. As previously discussed, the majority of recovery furnaces being installed are the non-contact type furnaces which do not require BLO systems to achieve the NSPS. This trend towards non-contact furnaces existed before promulgation of the NSPS and is expected to continue because of the economics of operating a non-contact furnace system in comparison with a direct-contact furnace system. Therefore, rescinding the BLO standard would have a minimal impact on TRS emissions.

8.1.7 Condensate Stripping Systems

TRS emissions from condensate stripping systems subject to the NSPS are controlled by incineration of the vent gases in either a lime kiln or separate incinerator. Incineration is the basis for the NSPS. There is no justification for revision to the present NSPS for condensate stripping systems.

8.1.8 Exemption for Brown Stock Washers and Black Liquor Oxidation Systems

Presently, the NSPS includes an exemption for new brown stock washer systems or black liquor oxidation systems where combustion of the vent gases in an existing facility is not feasible from a safety or economic standpoint. This provision [Section 60.283(a)(1)(IV)] was included because the EPA agreed with the industry's comment that older recovery furnaces do not have the capability to accept large volumes of gases, and the costs associated with altering these recovery furnaces could be prohibitive. Information obtained during the NSPS review indicates that power boilers instead of recovery furnaces are bein) used as the incin"ration device for the high volume gas streams. Discussions with mill personnel and an equipment vendor indicate no operating problems with using the power boiler as an incineration device.[2,7] The costs associated with using the power boiler would be similar to the costs presented in Table 6.1 which are based on using a new recovery furnace designed to handle the gases. However, the one mill which received an exemption from the NSPS only added a single additional washing stage. This was not an entirely new washer installation. A diffusion washer stage is not likely to be added to an existing vacuum drum washing line.[8] In addition, the power boilers at many existing mills may be physically located at a great distance from the washers. Therefore, there is not sufficient justification for removing this exemption.

8.2 POSSIBLE REVISIONS TO MONITORING REQUIREMENTS

The existing NSPS for kraft pulp mills require that continuous monitoring systems be installed, calibrated, maintained, and operated to measure:

1. Opacity and TRS emissions from the recovery furnace system,
2. TRS emissions from the lime kiln system, and
3. Combustion temperature at the point of incineration of gases which are emitted from digesters, multiple-effect evaporators, brown stock washers, black liquor oxidation systems, and condensate stripping systems.

The industry has commented that monitoring of combustion temperature is unnecessary when a power boiler, recovery furnace, or lime kiln is used as the incineration device, because the flame temperatures are typically 1600°F or higher. We agree that if compliance with the minimum temperature of 1200°F for at least 0.5 second has been demonstrated, there is no necessity

to monitor combustion temperature, since these devices will normally operate at temperatures higher than required by the NSPS. Therefore, there is sufficient justification to revise the NSPS to require monitoring of the combustion temperature only when the gases are combusted in an incinerator.

The volume concentration of TRS emissions can be monitored by use of monitoring systems. There are no process or control device parameters that are indicators of concentration of TRS emissions generated from recovery furnaces and lime kilns. As discussed in Chapter 2, TRS emissions from these sources are affected by many operating parameters. Therefore, since the gas stream TRS monitoring system is the only method of monitoring concentrations of TRS emissions from these affected facilities, there is no justification for revising the NSPS requirement for TRS monitoring. The continuous monitoring system specifications for TRS monitors are expected to be promulgated in the near future.

The only criticism voiced of the NSPS was excessive paperwork due to recordkeeping requirements. These recordkeeping requirements are specified in Section 60.7(b) and (c) of the general provisions for new source performance standards. Section 60.7(b) requires the operator of any source subject to a standard to maintain records of the occurrence and duration of any startup, shutdown, or malfunction in the operation of an affected facility, any malfunction of the air pollution control equipment, or any periods during which a continuous monitoring system or monitoring device is inoperative. Section 60.7(b) also requires any operator to maintain a file of all measurements, including continuous monitoring system, all continuous monitoring system performance evaluations, all continuous monitoring system calibration checks, and adjustments and maintenance performed on these systems. Section 60.7(c) requires the operator to submit a written report of excess emissions to the Administrator for every calendar quarter.

8.3 EXTENSION TO OTHER SOURCES

During the NSPS proposal (41 FR 42013), it was indicated that all process gas streams identified as major sources of TRS and particulates at kraft pulp mills were covered by the NSPS, except for power boilers and water treatment ponds. Power boilers are a source of particulate emissions

at kraft pulp mills. They were not included in the NSPS because the EPA intended to develop standards for industrial boilers which would include power boilers at kraft mills. The standard for industrial boilers is in the process of being proposed.

Water treatment ponds were considered to be potentially significant sources of TRS emissions at some kraft pulp mills. Standards for treatment ponds were not included in the NSPS, because methods of measuring TRS emissions from the ponds were not available, and further investigation of emission control techniques were needed. This rationale still applies; a proven sampling method is not yet available. It was felt that emissions from ponds could be controlled by treating the process condensate stream in a condensate stripper system prior to discharge to the ponds. However, bacterial action could generate additional TRS in some ponds. Most new pulping installations have installed condensate stripping systems for controlling either BOD, odor from recycle water, or odor from ponds. Therefore, there is presently no justification to revise the NSPS to include treatment ponds.

A development program for sampling hydrocarbon emissions from a pond is planned for another source category. Once the sampling method is demonstrated, it could be adapted for sampling TRS emissions. A testing program could then be performed to determine the magnitude of the TRS problem for analysis during the next review of the NSPS.

8.4 EXTENSION TO OTHER EMISSIONS

Kraft pulp mills are also sources of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon monoxide (CO) emissions. The recovery furnace, lime kiln, and power boiler have been identified as sources of SO_2. Power boilers, as stated in Section 8.2, are being covered under a separate industry category. EPA tests conducted during the NSPS development on two recovery furnaces and three lime kilns show SO_2 emission levels of about 2.0 g/kg ADP (about 70 ppm) and 0.15 g/kg ADP (about 30 ppm), respectively. Revisions to the NSPS to include SO_2 emissions from recovery furnaces and lime kilns are not justified at the present time because no demonstrated control techniques, considering costs, have been identified for these

facilities. A study should be performed to investigate the magnitude of SO_2 emissions from recovery furnaces, the factors that affect emissions, the emission control methods available, and to determine whether regulation is appropriate.

Recovery furnaces and lime kilns are also sources of CO and NO_x. CO emissions were measured by the EPA during the NSPS development on two recovery furnaces and showed levels of about 1.3 g/kg ADP (about 100 ppm). CO emissions from lime kilns average about 5 g/kg ADP. EPA tests on two recovery furnaces showed NO_x levels of about 1.0 g/kg ADP (about 50 ppm). NO_x emissions from lime kilns at kraft pulp mills are estimated to be about 0.6 g/kg ADP (150 ppm).[9] Revisions to the NSPS to include CO and NO_x emissions are not justified, since no control techniques have been demonstrated in the kraft pulping industry for these facilities.

8.5 REFERENCES

1. Letter and enclosure from John E. Pinkerton, NCASI, to James A. Eddinger, U.S. EPA, dated April 8, 1983.

2. Trip Report - Champion International Corporation, Courtland, Alabama, May 20, 1982.

3. Memo from Janis Forehand, EPA Region VI, to Jim Eddinger, EPA, dated June 29, 1982.

4. The Effect of a Wet-Bottom Precipitator upon Recovery Furnace TRS Emissions, NCASI Atmospheric Quality Improvement Technical Bulletin No. 98, September 1978.

5. Letter from Alan M. Lindsey, International Paper Company, to Jack R. Farmer, U.S. EPA, dated April 22, 1983.

6. Meeting Report - Industry Representatives and EPA Personnel, Durham, North Carolina, April 14, 1983.

7. Telephone Conversation between James Dickinson, Babcock & Wilcox Company, and James Eddinger, U.S. EPA, on September 9, 1982.

8. Letter from Keith M. Bentley, Georgia-Pacific Corporation, to Jack R. Farmer, U.S. EPA, dated April 22, 1983.

9. A Study of Nitrogen Oxides Emissions from Lime Kiln, NCASI Technical Bulletin No. 107, April 1980.

9. CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this report has been to assess the need for revision of the existing NSPS for kraft pulp mills. Conclusions pertaining to the particulate and TRS standards are reviewed below.

9.1 REVISION OF THE CURRENT STANDARDS

9.1.1 Conclusions Based on Control Technology

° Since the standards were originally promulgated, no new control technology has emerged. Compliance test results for facilities subject to the NSPS indicate that all are in compliance with the NSPS, except for two recovery furnaces and one smelt dissolving tank which have not been able to meet the TRS standard.

° Four of eight recovery furnace installations with wet-bottom ESP's using unoxidized black liquor have experienced an increase in TRS emissions through the ESP resulting in TRS emissions above the NSPS. Modifications made to one installation resulted in the unit achieving compliance. Modifications made to the other four installations resulted in decreased levels, but above the NSPS. Further modifications to these units are being investigated by the companies.

° Compliance test results indicate that there is a larger range of variation in TRS emissions from well-controlled smelt dissolving tanks than indicated by data obtained during the NSPS development.

° Most lime kilns subject to the NSPS have demonstrated compliance with the TRS standard without caustic addition. Presently, the mills are not required to continuously monitor the TRS emissions. Until continuous monitoring data are available, insufficient data exist for making any judgement about the ability to continuously achieve the TRS standard without caustic scrubbing.

9.1.2 Conclusions Based on Economic Considerations

° There are 14 new recovery furnaces, 16 new smelt dissolving tanks, and 19 new lime kilns in operation which are subject to the NSPS.

° The growth rate averaged 3.5 percent per year between 1978 and 1981. The forecast is for a 2.3 percent decline in overall industry production in 1982, with a 4.6 percent growth in 1983.

° It is cost effective to control particulate sources since the recovered particulates are valuable materials.

° The cost effectiveness of the various TRS controls ranges from zero dollars per ton for the smelt dissolving tank to $9,250 per ton for the black liquor oxidation system. The brown stock washer system with a cost effectiveness of $2,500 per ton is the only other affected facility with a cost effectiveness about $1,000 per ton. However, this cost was based on the use of a vacuum drum type washing system, and newer mills are installing diffusion washers with a cost-effectiveness of $900 per ton of TRS controlled.

° The high cost effectiveness of the BLO systems is due to the small amount (16 tons per year) of TRS controlled.

9.1.3 Conclusions Based on Other Considerations

° If compliance with minimum temperature of 1200°F for at least 0.5 second has been demonstrated, there is no necessity to monitor combustion temperatures from devices other than an incinerator, since these devices will normally operate at temperatures higher than required by the NSPS.

° There are no process or control device parameters that are indicators of concentration of TRS emissions generated from recovery furnaces and lime kilns.

° Method 16A is equivalent to and less expensive than Method 16.

° The present NSPS prevents the use of Method 16A to determine compliance for smelt dissolving tanks.

° High volume, non-condensable gases from facilities subject to the NSPS are generally incinerated in a power boiler instead of a recovery furnace. Power boilers are used at all kraft pulp mills.

9.1.4 Recommendations on Revision of Current Standard

Based upon the technological, economic, and monitoring conclusions, the following recommendations are made:

° Revise the existing TRS standard for the smelt dissolving tank to raise the standard to the level indicated by compliance data.

° Revise the NSPS to rescind the requirement for controlling TRS emissions from black liquor oxidation systems.

° No revision of either the particulate or opacity standards should be considered at the present time.

° No revision to the other TRS standards (other than for the smelt dissolving tank and BLO system) should be considered at the present time.

° Revise the units of the TRS standard for smelt dissolving tanks from g/kg BLS to g/kg BLS as H_2S to permit the use of Method 16A.

° No revision to the exemption for brown stock washer systems where combustion of these gases in an existing facility is not feasible from a safety or economic standpoint should be considered at this time.

° Revise the existing NSPS to rescind the requirement for monitoring the combustion temperature when a device other than an incinerator is used (i.e., the lime kiln, recovery furnace, or power boiler), if compliance with a minimum temperature of 1200°F for at least 0.5 second has been demonstrated.

° No revision of the TRS monitoring requirements should be considered at the present time.

9.2 EXTENSION OF STANDARDS

9.2.1 Conclusions Based on Control Technology

° Cost-effective control of sulfur dioxide has not been demonstrated in the kraft pulp industry.

° Control of nitrogen oxides and carbon monoxide has not been demonstrated in the kraft pulp industry.

° Control of power boilers will be regulated under standards being proposed for industrial boilers.

° Methods of measuring TRS emissions from water treatment ponds are not available.

9.2.2 Recommendations on Extension of Standards

° Standards for other processes and pollutants should not be considered at the present time.

° A study should be performed to investigate sulfur dioxide emission control methods available and to determine whether regulation is appropriate.

APPENDIX A
Kraft Pulp Mills Subject to NSPS

Company	Location	Sources
Champion International	Courtland, Alabama	Recovery Furnace Smelt Dissolving Tank Lime Kiln Digester Black Liquor Oxidation System Multiple-Effect Evaporators Brown Stock Washer System Condensate Stripper System
Union Camp	Prattville, Alabama	Recovery Furnace Smelt Dissolving Tank Lime Kiln Multiple-Effect Evaporators Brown Stock Washer System Digesters (2)
Container Corporation	Brewton, Alabama	Digesters
Hammermill Paper	Selma, Alabama	Recovery Furnace Smelt Dissolving Tank Lime Kiln Multiple-Effect Evaporators Digesters Brown Stock Washer System
Nekoosa Paper	Ashdown, Arkansas	Recovery Furnace Smelt Dissolving Tank Lime Kiln Black Liquor Oxidation System Digesters Multiple-Effect Evaporators Brown Stock Washer System
Georgia-Pacific	Crossett, Arkansas	Recovery Furnace Smelt Dissolving Tank Lime Kiln Multiple-Effect Evaporators
Simpson Paper	Anderson, California	Lime Kiln
Buckeye Cellulose	Perry, Florida	Lime Calciner
Container Corporation	Fernandina Beach, Florida	Cross Recovery Furnace Smelt Dissolving Tank
Georgia Kraft	Rome, Georgia	Lime Kiln

Company	Location	Sources
Continental Forest	Port Wentworth, Georgia	Recovery Furnace Smelt Dissolving Tank Lime Kiln
Buckeye Cellulose	Oglethorpe, Georgia	Recovery Furnace Smelt Dissolving Tank Lime Calciner Digester Multiple-Effect Evaporators Brown Stock Washer System Condensate Stripping System
Western Kraft	Hawesville, Kentucky	Lime Kiln Brown Stock Washer System
Continental Forest	Hodge, Louisiana	Multiple-Effect Evaporators
International Paper	Mansfield, Louisiana	Recovery Furnace (2) Smelt Dissolving Tank (2) Lime Kiln Digesters (3) Multiple-Effect Evaporators (2) Brown Stock Washer System (3)
Boise Cascade	Rumford, Maine	Recovery Furnace Smelt Dissolving Tank
Champion International	Missoula, Montana	Recovery Furnace Smelt Dissolving Tank Lime Kiln Digesters Multiple-Effect Evaporators
deral Paperboard	Riegelwood, North Carolina	Digesters Multiple-Effect Evaporators
se Cascade	St. Helens, Oregon	Lime Kiln
ernational Paper	Gardiner, Oregon	Recovery Furnace Smelt Dissolving Tank Lime Kiln Digester Multiple-Effect Evaporators Condensate Stripper System Brown Stock Washer Systems
national Paper	Georgetown, South Carolina	Lime Kiln
ssee River	Counce, Tennessee	Recovery Furnace Smelt Dissolving Tank

Company	Location	Source
Continental Forest	Hopewell, Virginia	Recovery Furnace Smelt Dissolving Tank
Crown Zellerbach	Camas, Washington	Lime Kiln
Longview Fibre	Longview, Washington	Lime Kiln
Boise Cascade	Wallula, Washington	Recovery Furnace Smelt Dissolving Tank Lime Kiln